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Instruction Manual

Model 72BD

Digital Capacitance Meter

BOONTON ELECTRONICS CORPORATION

TEL: 201-887-5110
TWX: 710-986-8241
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N.J. 07054 USA

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CHAPTER I

INTRODUCTION

1.1 General

The Model 72BD Capacitance Meter provides instant, direct-reading, three-terminal and differential capacitance measurements from 0.001 to 2000 pF. This capacitance coverage is divided into four ranges, selected by panel push-buttons, remotely, or auto-ranged. These are arranged in a 2, 20, 200 and 2000 pF full-scale sequence. The digital display provides 4 digit readout, decimal point, -, overrange and pF indications. The solid-state design and the low-level crystal-controlled signal source contribute to the high stability and excellent reliability of the instrument.

The measurement of semiconductors is facilitated by the 15 mV rms level of the 1 MHz test signal, and by the provision for applying up to 600 volts of dc bias to the test specimen. Bias voltage, of either polarity, may be applied to either or both sides of the specimen.

The Model 72BD employs an unusual range-switching system using switching diodes and miniature reed relays; the elimination of the switch contacts from the measurement circuits assures a maximum of reliability and stability. The phase-sensitive detection system permits the measurement of even low-Q devices (down to Q = 1) without sensibly degrading the accuracy of the measurement.

Two plug-in test connection adapters are supplied with the Model 72BD. One of these, 72-4B, fitted with two sets of coaxial connectors, is intended for use with coaxial cables and remotely located test fixtures for both three-terminal and differential measurements. The other adapter, 72-5B, with two terminal posts, is used for wire-lead type components; differential measurements are not possible with this adapter.

A linear dc output is available at rear-panel terminals and at the appropriate pins on the rear edge connector. Binary coded decimal outputs are also available at the rear edge connector. These two features extend the range of applications beyond ordinary laboratory measurements to include production testing and integration into a controlled test system, using logic-level programming.

Remote ranging is controlled by grounding the manual disable terminal on the rear edge connector, disabling the front-panel range switches. Grounding any one of the four range-line terminals will then select that range, or auto enable will select autorange.

Connection to the edge connector should be made with an Amphenol Type 225-22221-101 plug, or equivalent.

CHAPTER II

SPECIFICATIONS

Capacitance Range:	0.001 to 2000 pF
Full Scale Ranges:	2, 20, 200, 2000 pF
Accuracy, Q > 5:	0.25% rdg + 0.2% fs* 2000 pF range: 0.4% rdg + 0.2% fs
Q = 1 to 5:	0.5% rdg + 0.2% fs* 2000 pF range: 2% rdg + 0.2% fs *Add 0.005 pF on lowest range
Resolution:	0.001 pF (one digit on lowest range)
Display:	LED, 4 digits, blanked at approximately 7% over full scale. Decimal points, overrange indicator, negative polarity and pF.
Data Outputs:	1, 2, 4, 8 BCD data, serial by digits. Overrange, underrange, encode complete, and polarity
DC Output:	2 volt fs adjustable ±2%; source resistance 1000 Ω Linearity 0.1% rdg + 0.005% fs 2000 pF range: 0.25% rdg + 0.01% fs

Test Signal: Freq. = 1 MHz, crystal-controlled, 15 mV rms level

External Bias

HI to GND	±200 V max.
LO to GND	±400 V max.
LO to HI	±600 V max. (floating supply only)

Commands: Logic-level inputs select manual disable, input ranges, autorange, encode hold and encode trigger, TTL compatible. Logic 0 $\leq$ 0.7 V; Logic 1 = 2.4 to 5.25 V.

Temperature Influence:

Temperature Range	Max. Influence
Reference 21° C to 25° C	0
Normal 18° C to 30° C	0.2% of rdg
Extreme 10° C to 40° C	0.5% of rdg

Autoranging: Automatically upranges at approximately 2150, downranges at approximately 200. Ranging time is 100 ms per range.

Accessories Furnished: Two connection adapters:

a. 72-4B BNC for remote connections to TEST and DIFF terminals

b. 72-5B grip-posts for local connection of axial-lead components.

Accessories Available:	Model 92-1A rack-mounting kit. Kit for mounting one 72BD as one half of a module in a standard 19 inch rack. Model 92-1B double rack mounting kit. Kit for mounting two 72BD's side by side in a standard 19 inch rack.
Power Requirements:	100, 120, 200, 240 V ac ±10%, 50 to 400 Hz 13 watts
Dimensions:	5.2" high, 8.3" wide, 12" deep (132 x 211 x 305 mm)
Weight:	7 lbs. (3,15 kg)

CHAPTER III

OPERATION

3.1 Installation

Each instrument has been inspected and tested at the factory for full compliance with all specifications before packing. Should any indication of shipping damage be apparent upon unpacking, be sure to notify the carrier and the factory immediately. It is recommended that the special packing materials be saved for use in the event that the instrument must be re-shipped in the future.

3.1.1 Operating Controls and Indicators

ITEM	FUNCTION
FULL SCALE pF	These push-button switches select the full-scale range of the instrument (2, 20, 200 and 2000 pF). The AUTO switch at the bottom of the row activates the autoranging circuits and disengages the range switches.
PWR Switch	This rocker-type switch controls the primary ac power to the instrument. The translucent plastic rocker also serves as the pilot lamp.

ZERO Control — This control operates a differential capacitor used to balance out capacitance appearing across the TEST terminals contributed by the exposed termination of connecting cables, test fixtures, etc. Control has a range of approximately plus and minus 5 pF.

Indicator — LED type, 4 digits decimal point, negative polarity, overrange, and pF.

(The following items are on the rear panel.)

BIAS Terminals — External dc bias may be applied to the HI and LO TEST terminals via these posts. The maximum values are ±200 volts from HI terminal to ground, and ±400 volts from the LO terminal to ground. It is necessary that the terminal not being biased be connected to ground. The sum of these two voltages (600 V) may be applied between the HI and the LO posts, but the bias supply should be floating (no connection to ground) for this application.

LINE VOLTAGE SWITCH — This switches the power transformer primary for 100, 120, 220 or 240 volts, in accordance with the available line voltage.

Fuse Holder	Contains the power line fuse: 0.2 ampere for 100/120 volts, and 0.1 ampere for 220/240 volts.
ANALOG Terminals	A dc voltage proportional to the capacitance reading is available at these terminals. This voltage is 2.0 volts adjustable ±2% of full scale range on each range. Source resistance is 1000 ohms, linearity 0.1% rdg ±0.005% fs.
P102	22-pin edge connector for remote ranging and readout connections. Also bias and analog connections are available on this connector. (See Figure 9.)
⚠	This safety requirement symbol has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, paragraph 5.3 which directs that an instrument be so labeled, if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source.

3.2 Operation

3.2.1 See that the rear-panel voltage selector switch is in the proper position for the line voltage used, and that the correct fuse for this voltage is in the fuse holder. Plug the power cord into a receptacle, turn the instrument on, and allow it to warm up for a few minutes.

3.2.2 Plug the desired test connection adapter into the front panel receptacle. Test adapter is held in place by a captive screw located in the center of the adapter. If it is planned to test components remotely via coaxial cables or with a test fixture, all of these items should be connected to the adapter jacks at this time.

3.2.3 Push the 2 pF range button switch and set the indicator reading to zero, using the ZERO control.

NOTE: The ZERO control uses a dual-ratio vernier to drive a variable air capacitor with a full 360° rotation. The ZERO control turns easily for about 270°, at which point the ratio shifts from 36:1 to 6:1 and torque increases abruptly.

3.2.4 When more than a few inches of coaxial cable is used to connect the instrument to a remote test fixture some attention must be given to the loading capacitance

of the cable. To maintain the specified accuracy, the values shown in the following table should not be exceeded.

Maximum Cable Loading Capacitance

A. HI post to ground:

RANGE	MAX. C
2 pF	200 pF
20 pF	500 pF
200 pF	"
2000 pF	"

B. LO post to ground:

500 pF max. on all ranges

3.2.5 The instrument is now ready for use. The zero setting should hold on all ranges once it has been made on the 2 pF range. In the autorange position, the zero adjustment should be made with the instrument in the autorange mode.

3.2.6 The ZERO adjustment has sufficient range to compensate for approximately 5 pF of shunt capacitance across the TEST terminals. If this range is insufficient, a small capacitor (value determined experimentally)

can be connected across the DIFF terminals to effect zero setting within the range of the ZERO control.

3.2.7 Remote Measurement

The remote measurement of capacitance via coaxial cables introduces a measurement error owing to the transmission line effect on the test voltage transmitted from the LO terminal, and on the received current at the HI terminal.

The combined effect is such that the ratio of measured capacitance to actual capacitance is:

$$Cm/C = \frac{1 + j\omega Cr}{\left[\cos\beta\ell - \omega CZ_o(\sin\beta\ell)\right]^2 \left[1 + j\,\frac{\omega Cr(\cos\beta\ell) + (\sin\beta\ell)\, r/Z_o}{\cos\beta\ell - \omega CZ_o\,(\sin\beta\ell)}\right]}$$

where $\beta\ell$ = the electrical length of each line, in degrees

Z_o = the characteristic impedance of the line, in ohms

(Note: At 1 MHz, Z_o for RG-58/U is approximately 57.5 ohms.)

and r = the equivalent resistance of the Capacitance Meter from HI terminal to ground.

Range	r
2 pF	140 ohms
20 pF	7 ohms
200 pF and above	1 ohm

For the 72BD Capacitance Meter, the error is positive and its magnitude is shown in Figure 1 as a function of the measured capacitance, C_m, and cable length, ℓ.

The error is not shown for the lowest range for 12 foot lengths of cable, as the capacitive loading of the HI test terminal is excessive for lengths of RG-58/U greater than about 6.5 feet.

When calculating $\beta\ell$, which is the electrical length in degrees of each of the two cables, it is necessary to know the velocity of propagation of the cable at 1 MHz. Samples of RG-58/U which were tested indicate a relative velocity of 63.5%. The impedance of the same cable measured 57.5 ohms at 1 MHz.

It is imperative that the shields of both ends of the coaxial cable be tied together with a low resistance, low inductance strap for the correction curves and equation to be valid.

3.2.7.1 For short lengths of cable, a reasonable correction may be made based upon the effect of the series inductance of both lengths of cable. The measured capacitance, C_m, of a specimen will differ from the true capacitance, C_t, and the error will be seen as an apparent increase in capacitance in accordance with the following expression:

$$C_m = \frac{C_t}{1 - \omega^2 L C_t} = \frac{C_t}{1 - (X_L/X_{C_t})}$$

Or, if the true capacitance is required:

$$C_t = \frac{C_m}{1 + \omega^2 L C_m} = \frac{C_m}{1 + (X_L/X_{C_m})}$$

Where L = the combined series inductance of BOTH lengths of connecting cables and the inductance of the sample (generally small with respect to the cable's inductance).

As an approximation, the inductance of RG-58/U cable (with shields strapped at both ends) is about 0.091 μH/ft.

3.2.8 Differential Measurements

Measurement of the capacitance differential between two specimen capacitors can be made by connecting the lower value sample to the DIFF terminals, and the higher value to the TEST terminals. The display will indicate the capacitance difference between the two; by switching down to the next lower range, but never more than two ranges, the resolution can be improved. While capacitance may be measured using the DIFF rather than the TEST terminals (the display will then show the negative polarity sign), this is not recommended.

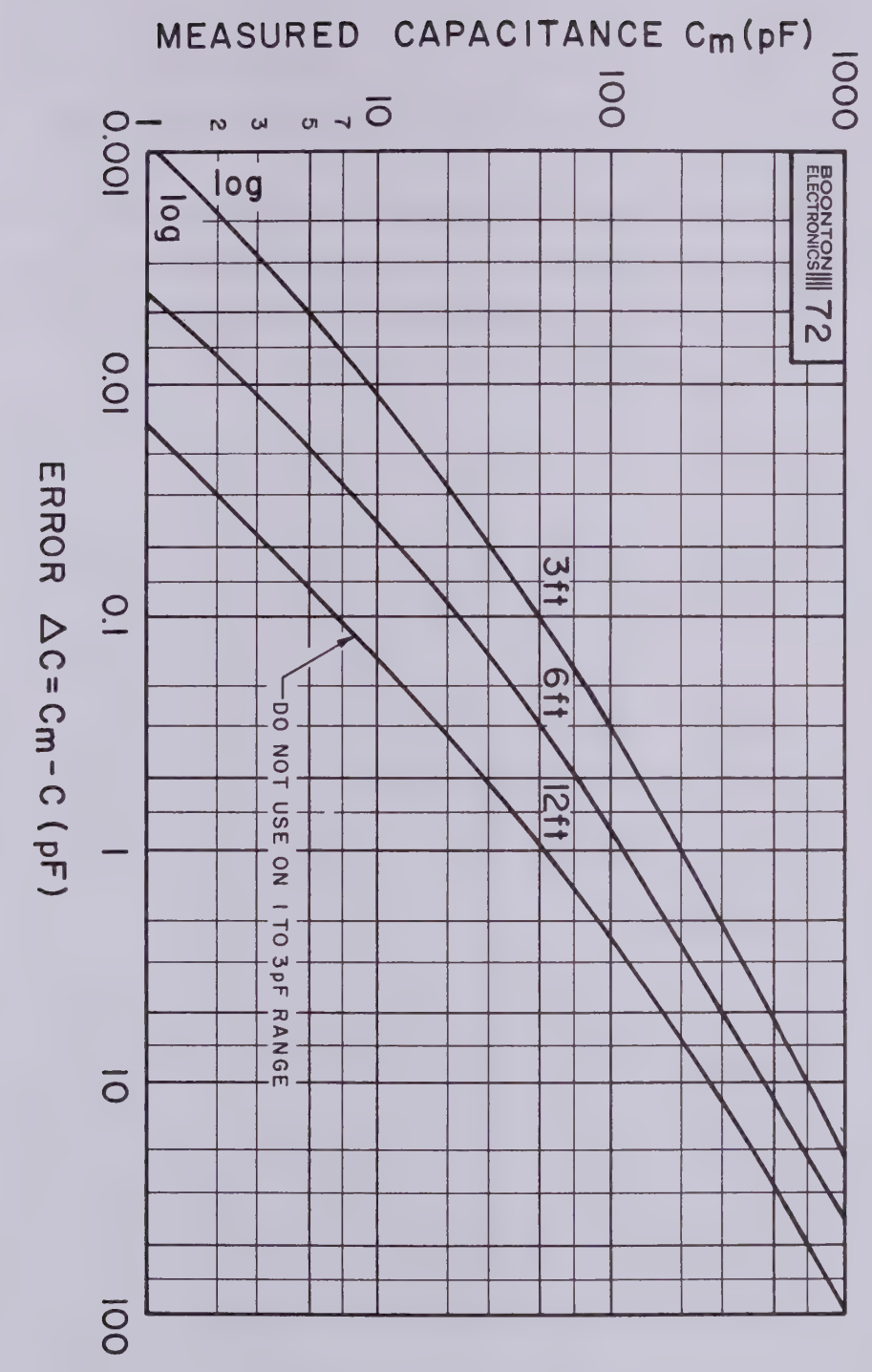


Figure 1. Capacitance Correction

NOTE: Differential measurements cannot be made with the instrument in the Autorange mode.

Excess fixture capacitance across the TEST terminals beyond the normal range of the ZERO control may be balanced out by the addition of a capacitor to the DIFF terminals (see Paragraph 3.2.6).

3.2.9 DC Bias

DC bias voltage may be applied to either or both sides of the specimen via the rear-panel bias terminals, or the proper pins on the rear edge connector. The applied voltages should not exceed ±200 volts from the HI terminal to ground or ±400 volts from the LO terminal to ground. When bias is applied to one side only, the other bias terminal must be connected to ground.

The sum of the two voltages (600 volts dc) may be applied between the HI and the LO terminals. In this connection, the bias supply cannot be grounded. An internal voltage divider of resistance values of 240 kΩ from HI to ground and 510 kΩ from LO to ground establishes the ground point. The bias lines are internally protected by 30 mA fuses.

3.2.10 External Triggering

To trigger an encode cycle, the trigger line (pin V on P102, rear edge connector) must be transferred from logic "1" to logic "0".

CHAPTER IV

APPLICATIONS

4.1 Transistor Parameters

The Model 72BD is capable of measuring the small-signal capacitance and forward gain parameters of both bipolar and unipolar transistors at 1 MHz. Capacitance and transconductance are measured with a test signal level of 15 millivolts; beta is measured with a base signal current of approximately 100 nanoamperes.

The principle of operation of the 72BD is fundamentally that of a transmission test set; the test capacitance is interposed between a low-level signal generator of fixed known amplitude and phase, and a calibrated phase-sensitive detector. It is evident that the forward gain parameters of transistors may also be measured, provided that the phase of the output current is proper, or suitably altered. The necessary external circuitry and components are described in the following text. Parameters that can be measured include the following:

4.1.1 Capacitance (Three-terminal)

NOTE: When measuring the capacitance of transistors, it is imperative to remember that a signal applied to the input of the test device will appear amplified in some form at the output (usually with a phase reversal). Capacitance measurements must be made with the output

of the device connected to the low test-terminal (generator) and the input of the device connected to the high test terminal (detector).

C_{iss} Input capacitance between gate and source with guarded drain. Device under test is fully biased. $V_{GS} = 0$.

C_{rss} Reverse transfer capacitance between drain and gate. Source guarded. Device under test is fully biased. $V_{GS} = 0$.

C_{eb} Emitter-to-base capacitance. Collector guarded. Emitter reverse biased. $V_{CE} = 0$ (o.c. for dc).

C_{ce} Collector-to-emitter capacitance. Base guarded. Collector reverse biased. $V_{BE} = 0$ (o.c. for dc).

C_{re} Collector-to-base capacitance. Emitter guarded. Device under test is fully biased.

C_{cb} Collector-to-base capacitance. Emitter guarded. Collector reverse biased. $I_E = 0$ (o.c. for dc).

4.1.2 Capacitance (Two-terminal)

C_{ob} Collector-to-base capacitance. Emitter is open-circuited for both ac and dc. Collector is reverse biased.

NOTE: External connections for the above measurements are shown in Figure 2.

4.1.3 Beta (h_{fe})

A sensibly constant base current, i_b, of 94 nanoamperes can be generated with the aid of a 1.0 pF capacitor connected between the low differential (LO DIFF) terminal of the 72BD Capacitance Meter and the base of the transistor under test. The collector current, which equals i_b, is fed to the high test terminal (HI TEST) and the instrument responds as though a capacitance of β times 1 pF were connected to its terminals. The value of indicated capacitance in picofarads is equal to beta (h_{fe}). The measurement of beta should be made under full bias conditions. In this arrangement, the base current is independent (very nearly) of the input resistance of the transistor, owing to the quadrature relation between the reactance of the current source and the input resistance.

The low differential terminal is used for the current source to offset the 180-degree phase reversal of current in the transistor.

The variable series capacitor in the base circuit (see Figure 3) must be adjusted for a value of 1.0 pF. This is simply accomplished by connecting a small jumper (unity-gain transistor) between the base and

collector socket terminals, which permits the direct measurement of this capacitance. If the LO DIFF terminal is used, the reading should be adjusted for -1.0 pF, or the LO TEST terminal may be temporarily used for a reading of +1.0 pF.

Should the transistor socket and its associated circuitry have excessive capacitance from the base terminal to ground, it can be absorbed with a simple parallel-resonant circuit, using a high L/C ratio for maximum impedance. (See Figure 3.)

4.1.4 Forward Transconductance (g_{fs})

The 72 Series Capacitance Meters are calibrated for an input current of $+je_g\omega C/\underline{\theta}$, where C is the full-scale value of capacitance for any given range. Connecting the gate of a unipolar transistor to the LO TEST terminal will, by definition, generate a drain current of $e_g g_{fs}$, provided that the external drain-circuit impedance is small. Unfortunately, the phase of the drain current lacks the required +90 degrees.

A network is needed which presents a low impedance to the drain, and which provides the necessary phase shift of +90 degrees. The circuit shown in Figure 4, Page 25, satisfies these conditions. The resistor R is the calibrating resistor for the full-scale value of g_{fs}. Its value is readily derived. The instrument is calibrated for a high-terminal current of,

$$i_c = e_g \omega C \angle 90^\circ$$

The actual drain current is,

$$i_d = e_g g_{fs}$$

The voltage induced in the secondary of the transformer is,

$$e' = j i_d \omega M \angle 90^\circ \text{ (polarity arranged for +M)}$$

To achieve a full-scale indication for a given value of g_{fs}, the resistor R must have the value,

$$R = e'/i_c = \frac{e_g g_{fs} \omega M \angle 90^\circ}{e_g \omega C \angle 90^\circ} = g_{fs} M/C$$

where

$R \gg \omega L_s$ for the current to have the correct phase; M is the mutual inductance of the transformer, and equals,

$$M = k\sqrt{L_p L_s}$$

The coefficient of coupling, k, may be easily measured by measuring the primary inductance with the secondary open-circuited, then short-circuited.

$$k = \sqrt{1 - (L_{sc}/L_{oc})}$$

If the resistor R is selected for a full-scale reading of 2000 μmhos on the 200 pF range, the instrument will read:

C Range	g_{fs} Range
200 pF	2000 μmhos
2000 pF	20,000 μmhos

A typical toroidal transformer might have the following circuit values:

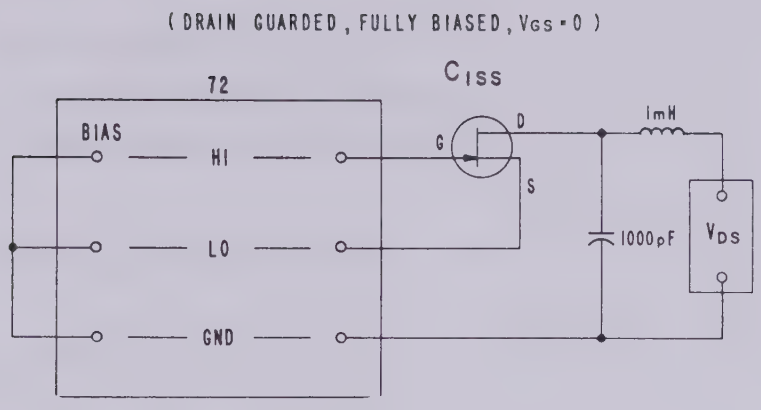
$L_p = 250$ μH
$L_s = 5$ μH
$k = 0.935$

from which,

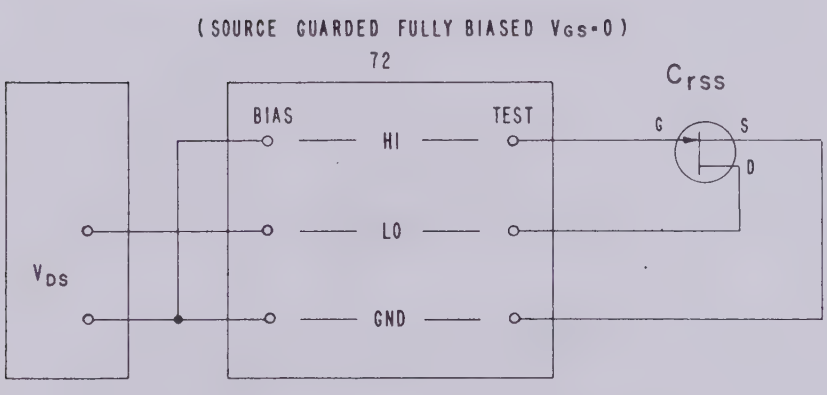
$M = 33$ μH

The series primary capacitance for resonance must equal 100 pF (approximately), and for a full-scale range of 2000 μmhos on the 200 pF range, the calibrating resistor should equal:

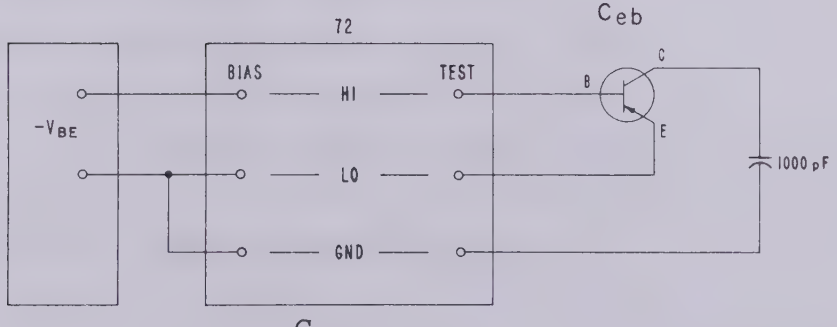
$$R - (2000)(33)/200 = 330\ \Omega$$



C_{iss}



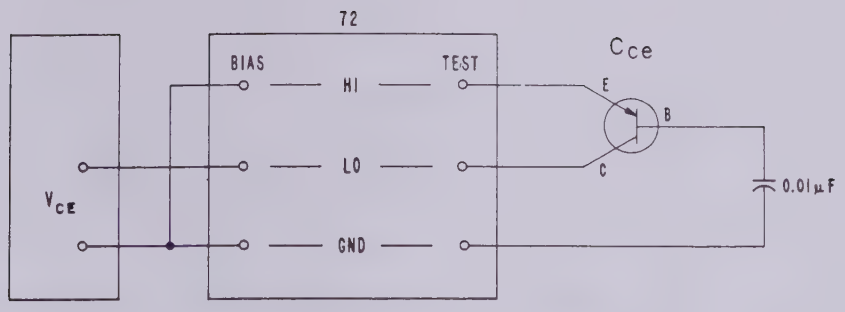
C_{rss}



C_{eb}

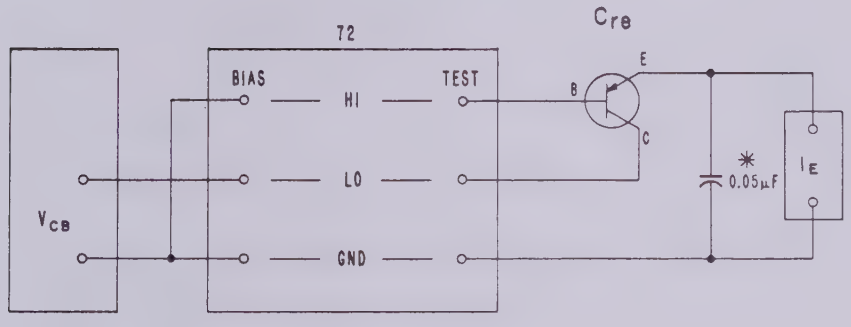
NOTE: Reverse bias on base emitter junction

Figure 2. Transistor Capacitance Measurements

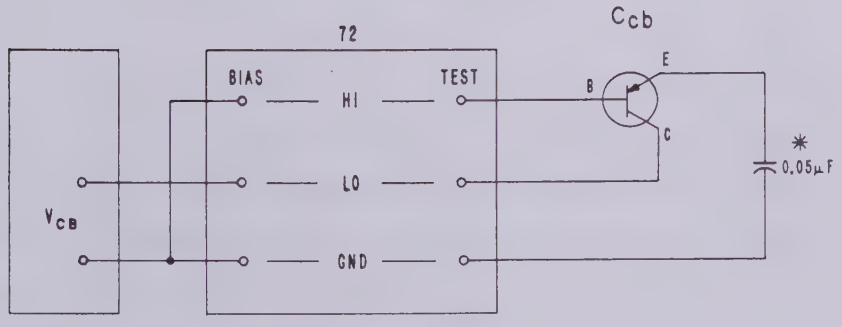


C_{ce}

(EMITTER GUARDED, FULLY BIASED)



C_{re}



C_{cb}

* A better by-pass obtains with a 2.5 μH inductor in series with a 0.01 μF capacitor.

Figure 2. (Cont'd.)

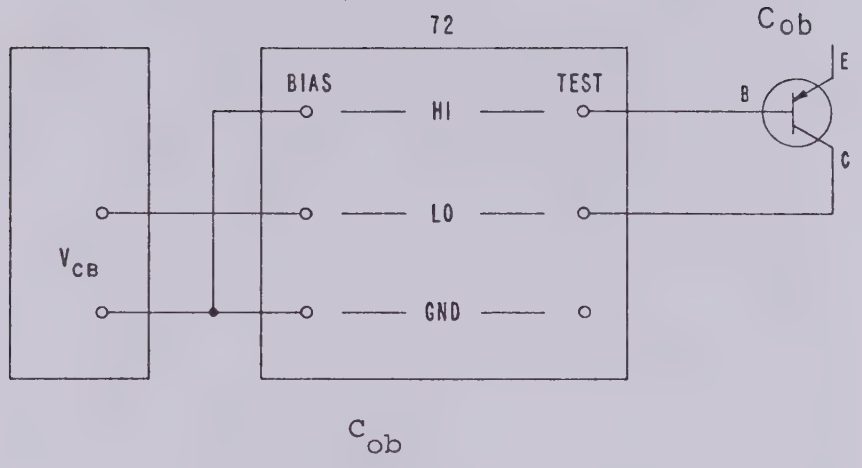


Figure 2. (Cont'd.)

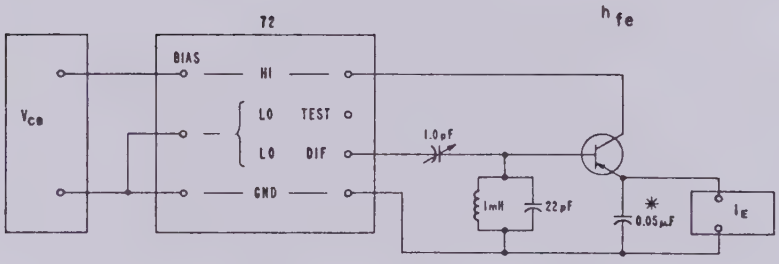


Figure 3. Transistor Beta Measurement

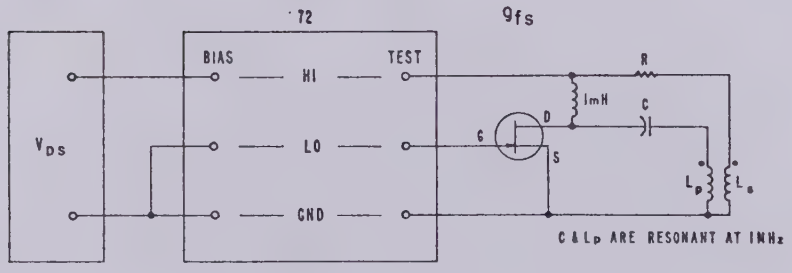


Figure 4. Transistor Transconductance Measurement

CHAPTER V

THEORY OF OPERATION

(Refer to the Simplified Schematic, Figure 5, in connection with this explanation.)

5.1 Measuring Circuit

The output of the 1 MHz crystal-controlled oscillator appears across the secondary of the input transformer whose center-tap is at RF ground. One end of this winding goes to the LO TEST terminal, and the other end to the LO DIFF terminal. The HI terminals are connected together and to the Ranging Circuits. A differential capacitor (ZERO) has its stators connected across the transformer secondary winding, and its rotor to the common HI post connection.

With the instrument operating, and with both TEST and DIFF terminals open, the only signal appearing at the output of this section would be the result of the residual capacitances of the terminals and any fixtures connected to them. Adjustment of the differential capacitor (ZERO control) balances out this signal, within the limits specified in Section 3.2.6, resulting in zero output from the measuring section.

When a specimen capacitor is connected between the LO and HI terminals, a current directly proportional to its susceptance

flows through the low-impedance series-resonant LC circuit to ground. (The series-resonant circuits for each range are selected by the range switching circuits.) The resultant voltage appearing across the capacitive part of the series circuit is applied, through a tuned amplifier, to the synchronous detector.

The synchronous detector, gated by the crystal oscillator, converts the 1 MHz signal to dc and applies it to the dc amplifier section. The output of the dc amplifier is available at the ANALOG terminals. The dc output from the synchronous detector is processed in the digital control card for zero adjustments on 20 pF and 200 pF ranges before being applied to the DPM.

5.2 Ranging Circuits

Range switching in the 72BD is accomplished by a combination of panel switches, switching diodes, and miniature reed relays. The panel switches handle only control voltages; no signal currents pass through their contacts, which eliminates a frequent source of errors and improves reliability.

With a range switch open, the switching diode is biased off by the 2.4 volt differential between the +6.6 volts on its cathode and the +4.2 volts on its anode. When a range switch is closed, the cathode of the appropriate diode is grounded for dc through an rf choke and 10 kΩ resistor. As it then has a net positive bias on its anode, the diode is in a conduction state and thereby connects one end of its associated range network to the input of the 1 MHz amplifier. At the same time, the range switch

energizes the associated reed relay which connects the other end of the range network to the output of the measuring section.

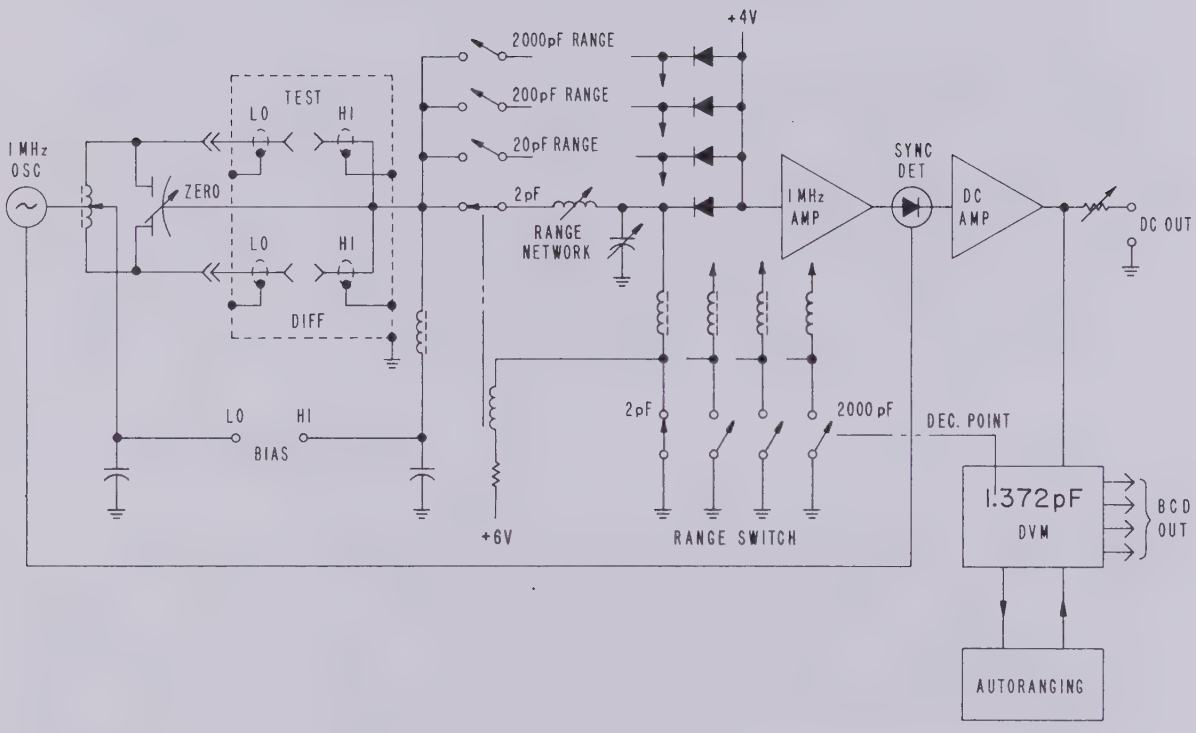


Figure 5. Simplified Schematic

CHAPTER VI

MAINTENANCE

NOTE: Values and tolerances shown in this section are not specifications but are provided only as guides to the maintenance and calibration of this instrument.

6.1 Introduction

The Model 72B/BD is designed to operate within stated specifications over a long period. However, to achieve the maximum performance it is desirable to check and adjust the instrument periodically. Basically, two adjustments are recommended:

a. A zero balance check and adjustment every 500 hours of operation (three months of normal use), and

b. A calibration check every 1000 hours of operation (six months of normal use).

In addition to these two periodic checks, complete adjustment procedures are described in paragraphs 6.4 to 6.9. It is felt, however, that after the complete calibration procedures performed at the factory, these adjustments are not needed when the instrument is used in normal laboratory or factory environment. It is recommended they be performed only in case of accidental misadjustment, component failure and replacement, or when the instrument has been subjected to severe environmental stresses, such as shock or vibration.

Complete schematics, parts lists and control and component location drawings are at the end of this manual and should be referred to when servicing is performed.

For all calibration checks a minimum one hour warmup is required.

6.2 Required Test Equipment

6.2.1 Digital or differential dc voltmeter, 0.001 - 100 V; ±0.05% accuracy. (Fluke Model 8100 or equivalent)

6.2.2 Electronic dc VOM, 1 MΩ input resistance, minimum

6.2.3 RF Millivoltmeter, 1 mV to 1 V, 1 MHz minimum bandwidth (Boonton Model 92B or 93A with high impedance probe)

6.2.4 Capacitance and Q Standards, 100 pF ±0.25% Q > 500 and Q ≈ 3 at 1 MHz (Boonton Model 71-1A), and a set of 1 MHz capacitance standards:

1000 pF ±0.1%
100 pF ±0.1%
30 pF ±0.1%
10 pF ±0.1%
1 pF ±0.1%

6.2.5 1 to 1000 pF ±0.25% Push Button Capacitance Standard (Boonton 71-3A)

6.2.6 200 pF ±5% loading capacitor (See Section 6.5.1.1.)

6.2.7 500 pF ±5% loading capacitor (See Section 6.5.1.1.)

6.3 Zero Adjustment

The zero adjustment should be performed whenever there is disagreement between higher range zeros after the zero has been adjusted on the lowest range with the front panel ZERO control. No standards or equipment are needed to perform this check and adjustment.

6.3.1 To check the zeros with no capacitance on the TEST terminal, set the Model 72B/BD to the lowest range and adjust the front panel ZERO control for zero indication. Now select all higher ranges and observe and record zero indications on all higher ranges. The indications should not exceed ±0.5% fs on Model 72B or ±2 lowest counts on the Model 72BD. If the zero indication exceeds these limits, proceed as follows:

6.3.2 Model 72B zero adjustment

6.3.2.1 Turn the instrument OFF and check the indicator pointer in normal instrument operation position. Adjust the meter zero (black screw below the dial) to indicate exactly zero.

6.3.2.2 Turn the instrument on, connect the BNC adaptor to the instrument, but use no capacitor, and adjust the front ZERO control on the 1 pF range until the instrument indicates zero.

6.3.2.3 Select the 1000 pF range and adjust R133 at the rear until the instrument indicates zero on the 1000 pF range.

6.3.2.4 Set the instrument to the 1 pF range and adjust the front ZERO again. Now check all other ranges, which should be in the ±0.5% fs limits.

If desired, the 1000 pF range zero (R133) may be reset slightly to make the maximum positive zero deviation equal to the maximum negative deviation. This will minimize the zero error when the instrument is used on different ranges without front ZERO adjustment.

6.3.3 Model 72BD zero adjustment

6.3.3.1 Connect the BNC adaptor to the instrument and remove the top cover. Select the 2 pF range and adjust the front ZERO to indicate 0.000.

6.3.3.2 Select the 2000 pF range and adjust R242 on the amplifier plug-in board for zero indication. Repeat steps 6.3.3.1 and 6.3.3.2.

6.3.3.3 Select the 200 pF range and adjust R316 on the digital control board for zero indication Select the 20 pF range and adjust R317 for zero indication.

6.3.3.4 Connect a sensitive DC voltmeter to the ANALOG OUT terminals at the rear and adjust R133 for an analog output less than 1 mV when the Model 72BD is on the 2000 pF range.

As adjusted above, the analog output at zero indication may vary by ±5 mV from range to range and cannot be adjusted by R316 and R317. They affect the DPM zero only.

6.4 Calibration Check

The calibration check should be performed periodically after approximately every 1000 hours of operation. For the calibration check a set of 1 MHz capacitance standards of 1, 10, 30, 100, and 1000 pF is needed.

6.4.1 To check the calibration allow a minimum of one hour warmup and adjust zero with the front ZERO control on each range before making measurements. Perform Zero Adjustment 6.3 if needed. Zeroing should be done with all connecting cables from the standard to the instrument in place but disconnected at the LO terminal of the instrument.

6.4.1.1 For Model 72B connect 1, 10, 30, 100, and 1000 pF standards and check the errors on the corresponding ranges. These errors should not exceed 0.5% on any range. Record the indications.

6.4.1.2 For Model 72BD check the 2, 20, 200, and 2000 pF ranges at midrange with the same set of standards. These errors should be within 0.5% of indication except on the 2000 pF range where the error may be 0.75% of indication.

Before making further adjustments, analyze the results. If all ranges have errors in the same direction and approximately by the same percentage, a simple test-level adjustment will correct the calibration. However, when ranges need adjustment in different directions (some have positive, some negative errors) or by different amounts, they have to be calibrated separately.

6.4.2 Model 72B Calibration Adjustment

When all ranges have drifted by approximately the same amount, a single test level adjustment will correct the calibration.

6.4.2.1 Test-Level Adjustment

For the test-level adjustment, warm up the instrument, remove the top cover, select the 100 pF range, zero the range as per 6.4.1 and connect a 100 pF ±0.1% standard to the TEST terminals. If the indication is not within 0.5% of the standard, adjust the ten-turn trimmer R202 on the amplifier plug-in board to give the correct reading within 0.1%. By this adjustment, indications on all ranges will be corrected by the same percentage. The test level is also changed by this adjustment but this change is usually insignificant. The zeros of the ranges will not be affected.

The same result may be achieved by adjusting R142 on the 100 pF range which corrects all "1" ranges and R146 on the 30 pF range which corrects all "3" ranges by the same percentage.

6.4.2.2 For individual range adjustments, the instrument's bottom cover has to be removed to allow access to calibration adjustments C111, C117, and C121 on the lower left side of the instrument. To shield the instrument during these adjustments, the instrument should be set on a plain aluminum sheet,

or use a test cover with appropriate access holes.

The adjustments should always start with R202 (6.4.2.1) on the 100 pF range because this adjustment affects all other ranges.

For the 1000 pF range, connect the 1000 pF ±0.1% standard to the TEST terminal and, using a 1/16" insulated screwdriver, adjust C121 for an indication within 0.1%.

For the 10 pF range, use a 10 pF standard and adjust C117.

For the 1 pF range, use a 1 pF standard and adjust C111.

For all "3" ranges, select the 30 pF range, use a 30 pF standard and adjust R146 at the rear of the instrument.

6.4.3 Model 72BD Calibration Adjustment

Model 72BD calibration follows the same pattern as the Model 72B calibration. If all ranges have similar errors, a single adjustment of R202 on the 200 pF range with a 100 pF standard will correct the calibration. (See 6.4.2.1.)

For individual range adjustments, follow procedure 6.4.2.2 and using 1, 10, and 1000 pF standards, adjust each range to indicate within 0.1% of the standard.

Sections 6.3 and 6.4 cover the recommended periodic calibration procedure of the Model 72B/72BD. The adjustments in the following section are not recommended to be performed periodically.

6.5 Maintenance and Repair Adjustments

The following adjustments are factory adjustments which are not affected by aging or drift of the components and therefore are expected to remain set during the life of the instrument. Furthermore, their effect on instrument accuracy is somewhat less than the effect of direct calibration adjustments.

Therefore, it is not recommended that the adjustments described below be made during periodic calibration routine. They should be adjusted only when certain characteristics they affect are known to be out of specification, in case of component replacement, accidental misadjustment or if the instrument is subjected to abnormal vibration, shock or frequent transportation.

The characteristic each adjustment controls and the method of adjustment is described below.

6.5.1 L102, L103 and L104 Loading Adjustment

The Model 72B/BD is designed for three-terminal measurement, i.e., it measures only the capacitive component between HI and LO terminals and ignores the "loading capacitance" from the HI terminal and/or the LO terminal to ground. If fixtures or cables with high loading capacitance are used to connect the test capacitance to the Model 72B/BD and an error more than specified is introduced, the loading adjustments L102, L103 and L104 should be adjusted. It should be kept in mind that long connecting cables themselves introduce measuring error, especially with high value test capacitance. This error should not be confused with loading error.

6.5.1.1 Loading Error Test

To test for loading error, special loading capacitors of 200 pF and 500 pF should be constructed according to the sketch below:

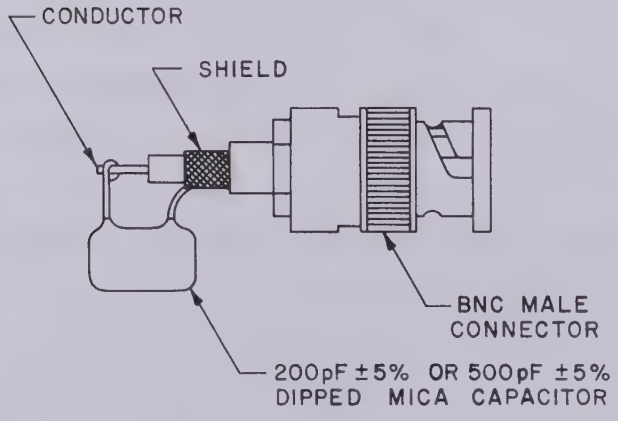


Figure 6. Loading Capacitor

To connect the loading capacitor and the test capacitor, use a BNC adaptor with two BNC "TEEs" as shown in the sketch below:

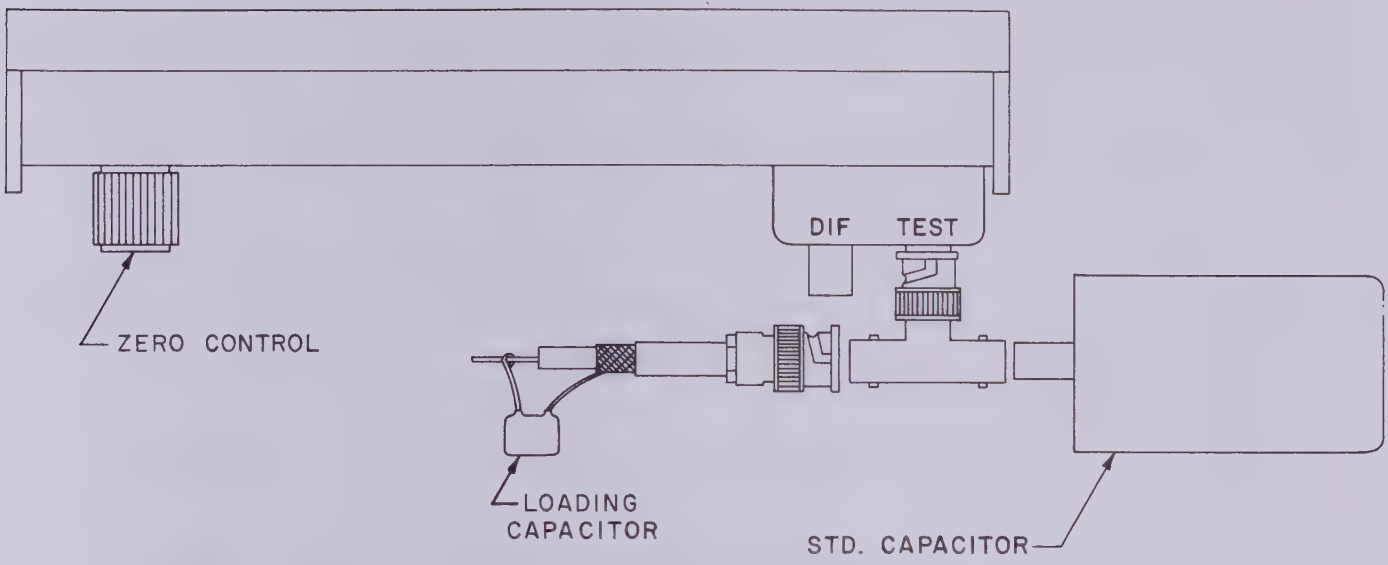


Figure 7. Loading Capacitor Test

For the loading test, select the desired range, connect the BNC adapter with two BNC TEE connectors as shown above, and zero the instrument with the front ZERO control.

Connect the standard capacitor to the right side of the TEE and record the instrument indication. Now disconnect the standard capacitor and connect the loading capacitor to the left side of the TEE on the HI terminal. Zero the instrument again, connect the standard capacitor to the right side of the TEE and measure the standard capacitor again.

The difference between indications should be within the following limits:

HI TERM LOADING	RANGE	MAX DIFFERENCE
200 pF	1, 2, or 3 pF	±0.25%
500 pF	10 pF and higher	±0.25%

When the HI terminal loading causes more error than listed above, adjust the loading coils as follows:

6.5.1.2 L102, L103, L104 Loading Coil Adjustments

Select the proper range, proper standards and loading capacitor. In Model 72B only "1" ranges have to be checked because the next higher "3" range uses the same input circuitry.

Zero the instrument and measure the standard capacitor; record the result. Now remove the standard capacitor, connect the loading capacitor to the HI terminal, zero the instrument again and connect and measure the standard capacitor again. If the measured value does not agree with the previous measurement, adjust:

(FS ranges with parentheses refer to 72BD, without parentheses to the 72B.)

Loading Adjustment	Range
L102	1, (2), 3 pF
L103	10, (20), 30 pF
L104	100, (200), 300 pF

1000 pF (2000 pF) range is adjusted with the 100 pF range adjustment.

The loading coil adjustment may affect calibration for the same range. Therefore the calibration has to be checked and adjusted per 6.4, if required.

LO terminal loading will not change during the life of the instrument and does not have to be checked.

6.6 HI - LO Q Adjustment C223, C228 and T201

Model 72B/BD measures only the capacitive component and ignores the resistive component of the current between HI and LO terminals. In order to accomplish this, the reference voltage to the phase detector should be in correct phase relationship to the signal voltage through the amplifier.

This is established by checking the instrument with high and low Q capacitors as follows:

6.6.1 HI - LO Test

Set the instrument to the 100 pF range, zero and connect HI-LO Q standard to the instrument. Make the capacitance measurement in HI and LO Q position of the standard and compare the results. If the results differ by more than 0.5%, HI-LO Q adjustments need readjusting.

If a HI-LO Q standard is not available, a simple substitute may be constructed as follows:

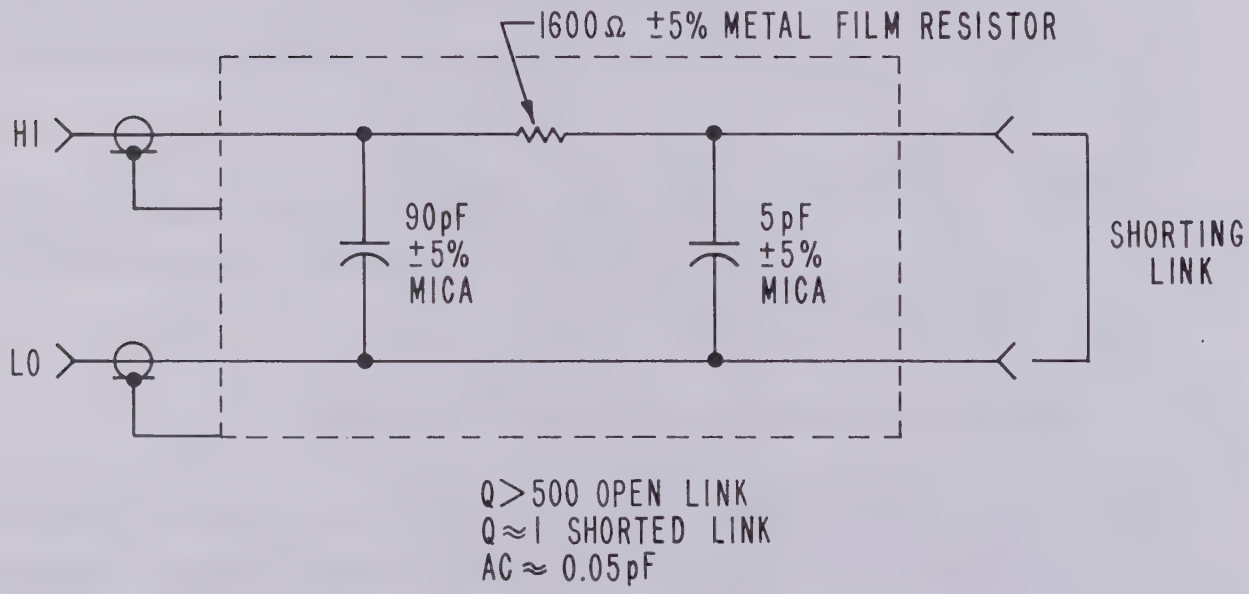


Figure 8. High - Lo Q Standard

6.6.2 HI - LO Q Adjustment

Set the instrument to the 100 pF (200 pF) range and zero with the front ZERO control. Connect a sensitive RF voltmeter to the test point TP3 and measure the RF voltage, which is typically 10 to 30 mV.

Adjust the phase detector balance with C233 for minimum indication on the RF voltmeter.

Now connect a HI-LO capacitance standard to the test terminal and make a measurement in the HI-Q position. Record the result. Make the same measurement in the standard's LO-Q position and adjust C228 until the HI and LO Q measurements agree within 0.25%.

If the range of C228 is not sufficient to bring the indications into agreement, transformer T201 core may be adjusted for the same purpose.

HI-LO Q adjustment may require the recalibration of the 100 pF range (see 6.4) as well as other ranges.

6.7 Input Transformer T401, C202 Tuning and Symmetry Adjustment

The input transformer should be tuned to the 1 MHz crystal frequency for proper operation of the oscillator. This may be accomplished either by the trimmer C202 or by adjusting the transformer core. The core adjustment should be used only when the range of C202 is not sufficient for proper adjustment.

6.7.1 T401, C202 Adjustment

To adjust trimmer C202, remove the top cover and connect an electronic dc voltmeter, 10 V range, to TP1 on the amplifier plug-in board. Adjust C202 for a maximum voltage on TP1, typically +7 to +12 V. If the maximum cannot be reached by adjusting C202, the core of transformer T401 may be adjusted. To adjust the core, remove the test adaptor and look for the adjustment hole between the upper banana terminals.

The core is normally fixed in its position either by a plastic lock nut or a small drop of Glyptol cement. If a lock nut is used, it may be unscrewed with a 1/8" wide blade screwdriver.

If no lock nut is used, the core may be adjusted directly with a 1/16" wide nonmetallic screwdriver. A drop of lacquer thinner applied to the core will loosen the core.

The core should be adjusted for maximum voltage on TP1, as described for the C202 adjustment.

After this adjustment, the instrument should be calibrated per section 6.4.2.1 and the core fixed in position with the plastic lock nut or Glyptol cement.

6.7.2 Test Voltage Symmetry Adjustment

The single-turn secondary of transformer T401 has an adjustable center tap by which the test voltage on TEST and DIFF terminals may be adjusted to be equal. The equality of TEST and DIFF voltages is important when an external standard is connected to the DIFF terminals for differential measurements. Normally the TEST and DIFF voltages are adjusted to be equal within 0.25%.

To adjust the symmetry, remove the top and bottom covers. Connect an accurate dc digital voltmeter to TP2 on the oscillator amplifier plug-in card. Adjust the front ZERO for zero indication on the DVM.

Plug a 100 pF capacitance standard first to the TEST and then to the DIFF terminals and observe the voltmeter indications. The voltmeter should indicate approximately +0.5 V at TEST terminal and -0.5 V at DIFF terminal. With a 1/16" blade screwdriver adjust T401 at the right side of the instrument until the magnitude of both indications is exactly equal for Model 72B. For Model 72BD the positive indication should be 20 mV higher than the negative indication.

This adjustment may require recalibration of test level per 6.4.2.1.

6.8 Power Supply Adjustments R116 and R118

R116 and R118 should be adjusted for +15 V, ±0.25 V, output from either power supply.

6.9 Digital Panel Meter Adjustments R1405 and R1408

The digital panel meter has two separate adjustments of sensitivity in the negative and positive directions. The nominal sensitivity of the meter is 0.5 V for 1000 indications.

For normal operation the exact adjustment of DPM is not needed because the measuring system sensitivity is calibrated to match the DPM. However, when the DPM is changed, the easiest way to calibrate the instrument is to adjust the DPM sensitivity to restore correct calibration.

To adjust the DPM, set the instrument to the 100 pF range, and zero the instrument with the front ZERO. Connect a 100 pF standard to the TEST terminal and adjust R1405 (right side control) for an indication of 1000.

Connect the 100 pF standard to the DIFF terminal and adjust R1408 (left control) until the DPM indicates -1000.

6.10 1 MHz Amplifier Tuning (L201 Adjustment)

For accurate adjustment of L201, the 1 MHz amplifier should be operated without overall feedback by unsoldering the link between the two solder terminals next to the L201 coil. Now the

amplifier gain is increased by approximately 30 db and the frequency response is very sharply peaked at 1 MHz.

To adjust L201, set the instrument to the 100 pF range, connect an rf voltmeter to TP3 and adjust the "ZERO" control until an indication of 0.2 to 0.5 V is observed on the rf voltmeter. Now adjust the core of L201 with a 1/16" insulated screwdriver (from the rear of the amplifier PC board) to peak the voltmeter indication to maximum.

On the Model 72BD the digital control PC board has to be removed for this adjustment. In any case a very short (0.5") screwdriver or extruder for the amplifier PC board is needed for this adjustment.

After adjustment, close the feedback loop by resoldering the link between the terminals. Test level adjustment per 6.4.2.1 may be needed after the L201 adjustment is made.

CHAPTER VII

TROUBLESHOOTING PROCEDURE

In case of instrument failure or malfunction a two-step approach to troubleshooting and repair is recommended:

a. Identify the defective section.

b. Troubleshoot and repair the section.

7.1 Identification of Defective Section

To identify a defective section use the troubleshooting diagram and the simplified troubleshooting schematic.

The instruments listed in section 6.2 are also sufficient for troubleshooting.

The diagrams should be sufficient to guide you through a logical troubleshooting sequence. The only point for attention is tp2 - the input to 1 MHz amplifier. Under normal operating conditions the signal level at this point is 150 μV at 1 MHz for a full scale indication on every "1" range. This signal is too low to be measured with the recommended instrumentation. Therefore introduce a 10 times overload (100 pF test capacitor on 10

pF range) to bring this level to a measurable range, for testing ranging circuitry.

7.2 Troubleshooting Defective Sections

The simplified troubleshooting schematic should be used to find the pertinent signal and dc voltage levels. This information together with specific tests recommended in the following section should enable an experienced troubleshooter to locate and repair defective components.

7.2.1 Power Supply

Normal output level

+15 V supply at +C128: +15 V ±0.25 V

-15 V " at -C129: - 15 V ±0.25 V

5 V " at +C405: +5 V ±0.2 V (72BD only)

When the output voltage cannot be set to the specified limit, check for an external short by checking the temperature of the series regulators (IC101, 102, and 103). High temperatures indicate external shorts; a cool regulator indicates trouble in the power supply or normal operation.

7.2.2 1 MHz Oscillator

Normal Operating Level

at LO terminal: 1 MHz, 15 mV ±2 mV

at tp1: +7.5 to +12 V dc

at J101 pin X: 1 MHz, 3.4 V

Check C202 or T401 tuning (6.7.1). When grossly out of tune, the oscillator will not oscillate.

7.2.3 Ranging Circuitry

Ranges are selected by reed relays K101 to K103 and switching diodes CR109 to CR112. If a particular range is activated, that reed relay is closed and its associated switching diode is forward biased.

Normal voltage levels are as follows:

	Pin 3 or 5 of IC106 or IC107	Pin D of J101
Range activated	0 V	4.2 V
Range not activated	+20 V	4.2 V

If IC106 or IC107 pin 3 or 5 voltage is pulled down when selecting the proper range but the range is not activated properly, look for trouble in the reed relays, switching diodes (CR109 to CR112) and associated circuitry.

If pin 3 or 5 voltage is not pulled down by range selection, the trouble is in the range switch, ranging lines or IC106 or IC107 packages.

"3" ranges in Model 72B are selected by decreasing indicator M101 current by opening K104 contact.

7.2.4 1 MHz Amplifier

The amplifier is a tuned feedback amplifier with closed loop gain of approximately 70 dB. The open loop gains by stages are approximately:

First Stage (Q203 and Q204): 54 dB
Second Stage (Q205): 23 dB
Third Stage (Q207): 23 dB

Output level of 0.5 V at TP3 is produced by input level of 150 μV at pin D of J101, which is too low to measure with normal instrumentation.

To troubleshoot the amplifier, check dc operating points and signal levels per the service diagram. Replace defective components, if needed. If this does not restore normal gain, check L201 tuning per (6.10).

The condition where the instrument operates normally on one or several ranges indicates that the trouble is in the ranging circuitry. The amplifier should not be serviced in this case.

7.2.5 Phase Sensitive Detector

Phase sensitive detector circuitry consists of bridge circuit CR205 to CR208 and overload detector Q208 and Q209.

Normal operating levels at full scale (100 pF on 100 or 200 pF range) are:

1 MHz amplifier output TP3: 1 MHz, 500 mV
Detector output at TP2: +0.5 V dc
Phase reference drive at C228: 1 MHz, 10 V

When the instrument is zeroed, the phase detector output at TP2 should be:

0 mV for Model 72B
approximately +10 mV for Model 72BD

Normal overload sensor voltage on pin S J101 is -15 V when indication is on range (1 MHz amplifier output at TP3 of up to 1.5 V, 1 MHz). With an overload condition (TP3 voltage above 1.8 V), the pin S voltage should change to +12 V.

7.2.6 Phase Reference Channel

Phase reference channel consists of reference amplifier Q206 and divider and phase shifting network. Normal operating levels are:

Input (Q206 base): 1 MHz, 4.8 V
Output at T201 secondary: 1 MHz, 10 V

T201 is tuned for maximum output at 1 MHz and finally adjusted for correct phase per (6.6).

7.2.7 Output Amplifier

Operational amplifier A101 drives the meter circuit and analog output. Normal operating level with 100 pF at the 100 pF (200 pF) range:

Input at pin 3: +0.5 V
Output at pin 5: +1.0 V

At overload, the overload signal causes the amplifier to clamp to maximum positive output; the overload signal is applied to pin 8 which voltage at normal range (up to 1.5 V at pin 3) is 0 and at overload (above 1.8 V at pin 3) is positive up to 12 V.

The input and output voltage of the Model 72B output amplifier will be zero if there is zero input to the Model 72B and the instrument is properly zeroed. In the Model 72BD, at zero indication, the input to A101 is approximately +10 mV which is balanced by a corresponding offset on pin 2 so that the output at pin 6 is zero.

7.2.8 Digital Control Circuit

The Digital Control circuits (Schematic 830651) in the Model 72BD control autoranging. Basically, the circuits consist of the following parts:

7.2.8.1 Zero control circuitry consists of dividers R315 to 318 and range switch IC308.

On the 2 pF and 2000 pF ranges, approximately 10 mV offset bias is introduced into LO DPM input (pin D of J102). This is compensated by a corresponding zero level from the phase detector. On ranges 200 pF and 20 pF, offset voltage may be varied with R316 and R317 to compensate for slight changes in zero offset on those ranges.

7.2.8.2 Overrange and underrange detectors are biased comparators IC304 to IC307. IC304 and IC305 detect underrange condition; IC306 and IC307, overrange condition.

Corresponding switching points and bias levels are as follows:

Condition	Normal Switching Point at	Limit Detector Bias
uprange pos. indication	2150 to 2180	+1.10 V at pin 3 IC306
uprange neg. indication	2150 to 2180	-1.10 V at pin 3 IC307
downrange pos. indication	200 to 210	+110 mV at pin 3 IC304
downrange neg. indication	200 to 210	-91 mV at pin 3 IC305

When the dc analog output (pin B) exceeds either uprange limit, it will pull IC306

output down and flip-flop IC311b will be clocked into a reset status by the clock pulse from IC301b. Clocking occurs on the falling edge of the clock pulse. Similarly, going below the low limit causes the output of IC305 to go high and sets flip-flop IC311a.

7.2.8.3 Clock and Counter Circuits

A 10 Hz clock IC301a and 301b activates a two bit up-down counter, IC309a and 309b, which is controlled by the signals from over or underrange flip-flops.

Gates IC313 and IC314 provide proper range commands to pins FHJK and range codes to pins MN of J102.

CHAPTER VIII

INTERFACE INFORMATION

8.1 Programming Inputs

Pin No.	Function	Comment	Command	Unit Loading
7	Man. disable	Disables front panel	0	1.25
6	Auto enable	Selects automatic ranging*	0	2
16	2 pF range	Selects range provided manual disable has also been selected, and autorange has not been selected; selecting more than one range will result in incorrect indications. Range lines must be deselected for either manual or auto ranging.	0	2
14	20 pF "		0	2
12	200 pF "		0	2
10	2000 pF "		0	2
X	Encode hold	Holds display	0	0.2
V	Encode trigger	Starts encode cycle	(See 8.1.3)	0.1

*Assumes that Man. Disable has also been selected

8.1.1 Input Characteristics

TTL Series	Logic Level	Voltage Level	Current per Unit Load
Standard Power 54/74	0	$\leq$ 0.7 V	-1.6 mA*
	1	2.4 to 5.25 V	40 µA

*The - current indicates current out of the input (external command device must sink this current). A standard power (Series 54/74) TTL output will sink and source 10 unit loads.

8.1.2 Input Pull-Up

All input terminals except encode trigger have internal pull-up. The current sourced by this pull-up when the input is brought to a logic level 0 is included in the loading shown in the "Unit Loading" column of the chart in 8.1.

8.1.3 Triggering

To trigger an encode cycle, the trigger line must be transferred from logic "1" to logic "0". Limits for trigger pulse characteristics are shown in 8.3.1.

8.2 Data Outputs

Pin No.	Function	Comment	True Logic Level	54/74 Unit Load
22	Polarity	Indicates negative reading	1	1
4	DC Analog	2 V for full scale	n/a	n/a
21	Overrange	Indicates that instrument range should be increased	0	1
20	Underrange	Indicates that instrument range should be decreased	0	1
W	Encode Complete	Indicates completion of encode cycle; data output may be read	1	1
17 18	21 range 20 code	Indicates range selected in binary code; 0 = 2 pF range, 3 = 2000 pF range	1	1
F E D C	8 4 BCD 2 enc. 1 data	Data in serial form, continuously scanned, left (MSD) to right, 500 µs/ digit, 2 ms scan	1 1 1 1	1 1 1 1
H J K L	4 3 Digit 2 select 1	Indicates digit to which BCD data applies; 4 = MSD (left-most)	1 1 1 1	1 1 1 1

8.2.1 Output Characteristics

TTL Series	Logic Level	Voltage Level	Current per Unit Load
Standard Power 54/74	0	$\leq$ 0.7 V	1.6 mA*
	1	2.4 to 5.25 V	-40 µA

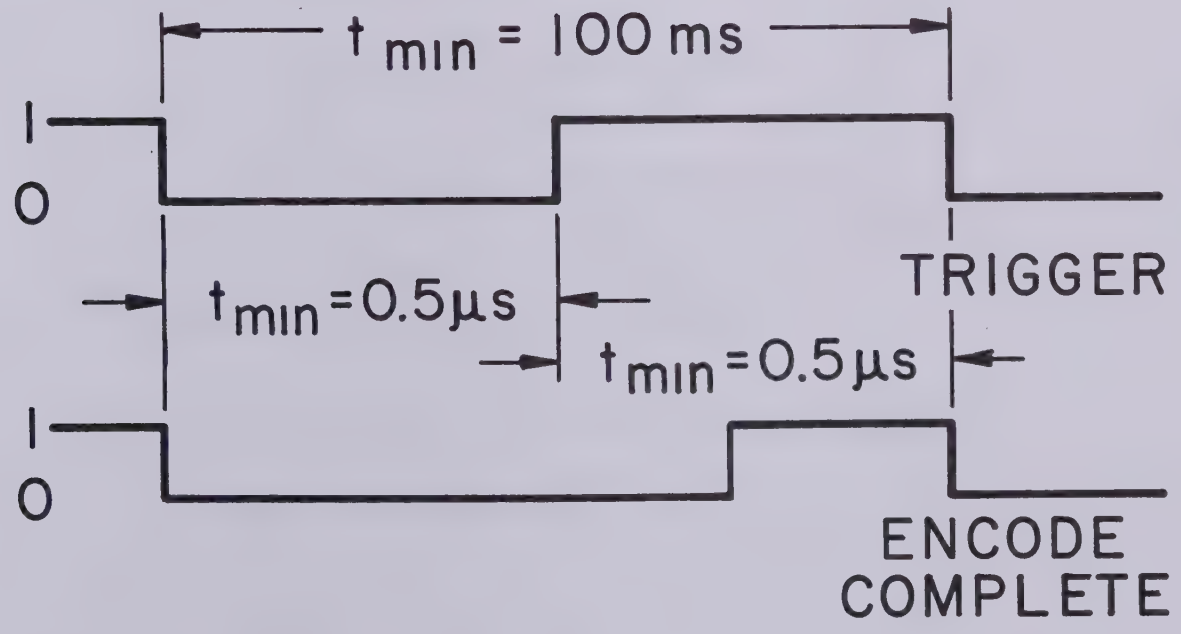
*The - current indicates current sourced by output.

8.2.2 Analog Output

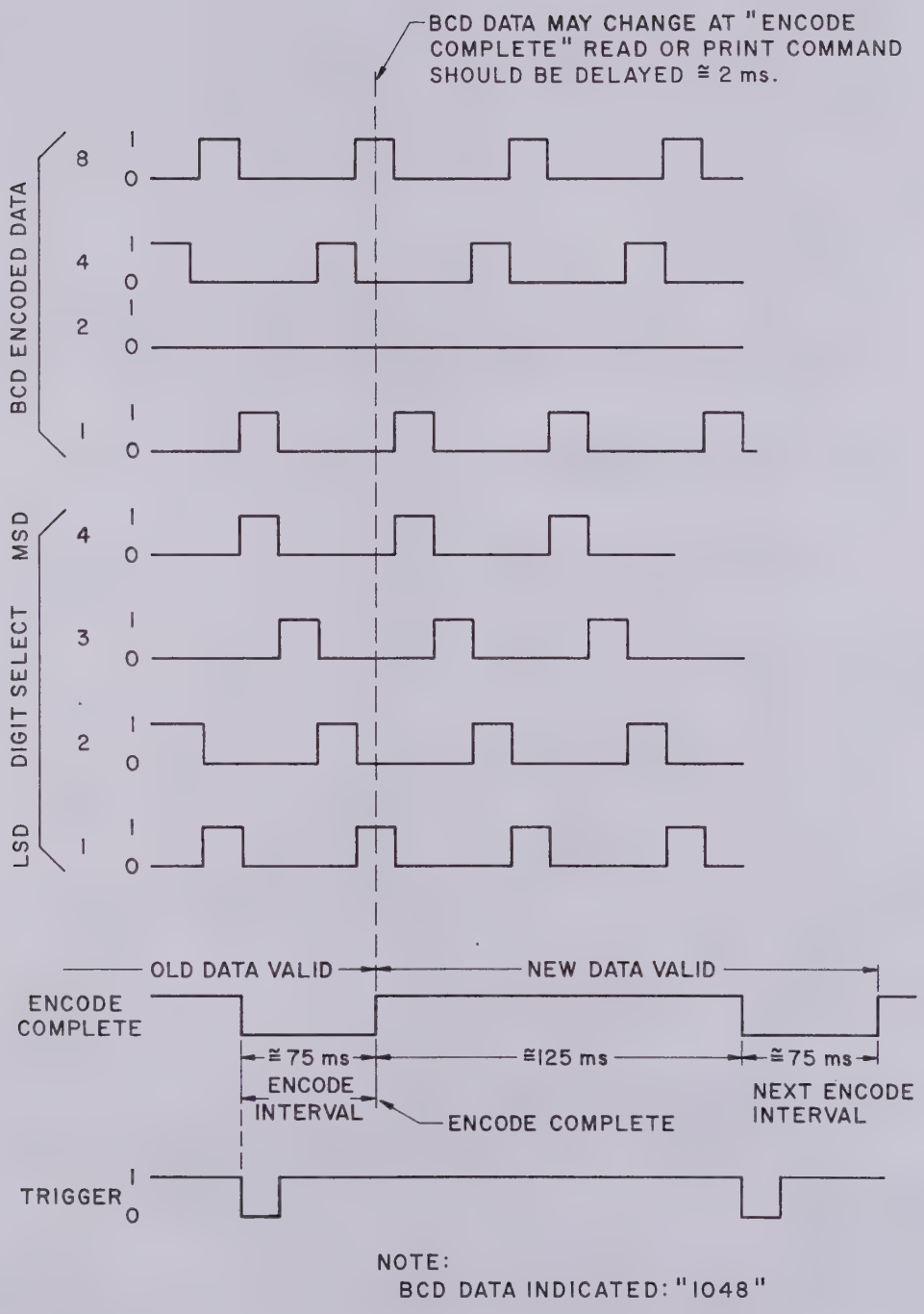
Source resistance is 1 kΩ.

8.3 Waveforms

8.3.1 Encode Trigger



8.3.2 Data Output Timing



8.4 Autoranging Characteristics

a. Instrument upranges at approximately 108% of full scale.

b. Instrument downranges at approximately 10% of full scale.

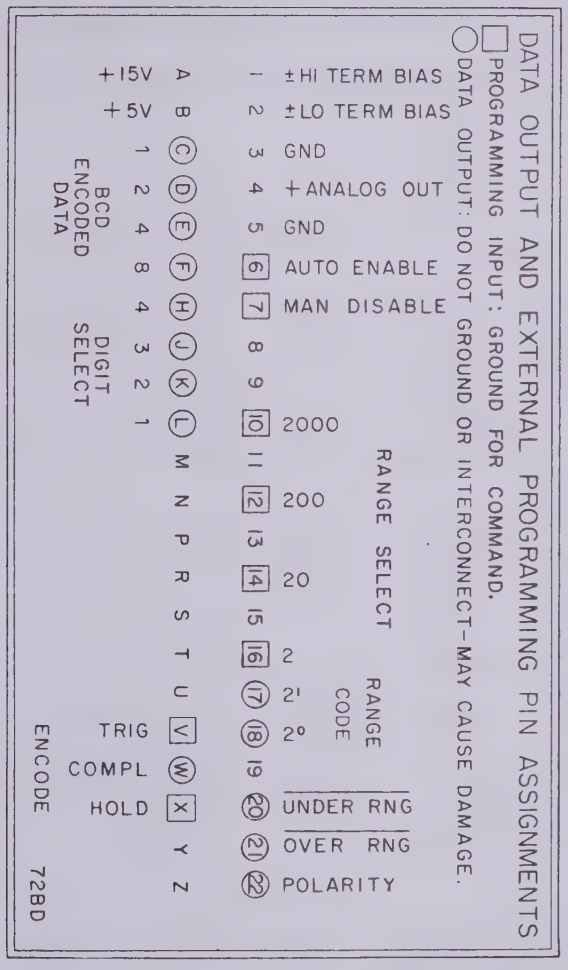


Figure 9. External Connections

8.5 Response to Input and Range Changes

8.5.1 Response to capacitance step changes

Analog output settles within 1 ms, and an encode cycle initiated after this delay will be accurate. Digitized data is available when "encode complete" comes "true", which requires from 50 to 75 ms following the trigger.

8.5.2 Response to capacitance range changes

The analog output settles within 10 ms. Observing this additional settling time, range changes may be treated as capacitance step changes (see 8.5.1).

8.5.3 Autorange response time

Final Range	Response Time
2 pF	300 ms
20	400
200	500
2000	600

8.6 "Encode Hold" Input

The "encode hold" input disables the internal encode trigger signal. It is normally used for two purposes:

a. To extend the interval between readings for a very slow output device such as a printer.

b. Whenever "external trigger" is used. Failure to enable the "encode hold" line will result in erratic triggering and readings. Note that the "encode hold" line may be enabled permanently if external triggering is always required in a particular application.

TABLE OF REPLACEABLE PARTS

MASTER BOARD

Reference	Description	BEC Part No.
A101	Amp. LM301 AN	535012
C101	Capacitor PC 0.1 µF 10% 630 V	234091
C102	" PC 0.47 µF 10% 630 V	234107
C103	" Mica 82 pF 5% 500 V	200074
C104	" Mica 100 pF 5% 500 V	200001
C105	" Mica 910 pF 1% 100 V	200075
C106	" Mica 0.01 µF 1% 300 V	203017
C107	" Mica 10 pF 5% (Factory	200022
	" Mica 5 pF ±1 pF Selected)	200043
C108	" Elec. 250 µF 40 V	283207
C109	" " " " " "	283207
C110	" Elec. 1000 µF 15 V	283221
C111	" Cer. Var. 2-20 pF Blue	281005
C112	" Mica 68 pF 5% 500 V	200031
C113	" Mica 82 pF 5% 500 V	200074
C114	" Mica 680 pF 1% 300 V	200015
C115	" Cer. 0.001 µF 500 V	224114
C116	" PE 0.1 µF 10% 100 V	234080
C117	" Cer. Var. 4.5-50 pF Green	281006
C118	" PE 0.1 µF 10% 100 V	234080

MASTER BOARD

Reference	Description	BEC Part No.
C119	Capacitor Cer. 0.001 µF 500 V	224114
C120	" PE 0.1 µF 10% 100 V	234080
C121	" Cer. Var. 4.5-50 pF Green	281006
C122	" PE 0.1 µF 10% 100 V	234080
C123	" Cer. 0.001 µF 500 V	224114
C124	" PE 0.1 µF 10% 100 V	234080
C125	" " " " " "	234080
C127	" " " " " "	234080
C128	" Elec. 100 µF 25 V	283105
C129	" " " " " "	283105
C131	" PE 0.1 µF 10% 100 V	234080
C132	" PE 0.022 µF 20% 250 V	234079
CR101	Diode Sig. 1N914	530058
CR102	" " "	530058
CR103	" " "	530058
CR104	" BR KBP-02	532013
CR105	" " "	532013
CR106	" " "	532013
CR107	" Sig. 1N914	530058
CR108	" " "	530058
CR109	" " "	530058
CR110	" " "	530058
CR111	" " "	530058

MASTER BOARD

Reference	Description	BEC Part No.
CR112	Diode Sig. 1N914	530058
CR114	" " "	530058
CR116	" " "	530058
IC101	I.C. μA7805	535011
IC102	" " "	535011
IC104	" " MFC 6030	535007
IC105	" " " "	535007
IC106	" " SN75451AP	534006
IC107	" " "	534006
IC109	" " SN74L00N	534002
IC110	" " N8471A	534005
J1201	Connector, 22 Pin	479259
K101	Relay Coil M/F 792151	470502
K102	" " " "	470502
K103	" " " "	470502
L101	Choke 560 μH	400183
L102	Coil 120-280 μH	400230
L103	" 14-28 μH	400231
L104	" 1.5-3 μH	400232
L105	Choke 4.7 μH	400113
L106	" 2.2 mH	400141
L107	" " "	400141

MASTER BOARD

Reference	Description	BEC Part No.
L108	Choke 2.2 mH	400141
L109	" " "	400141
L110	" " "	400141
L111	" " "	400141
P101	Terminal	477240
P104	"	477240
R101	Resistor Comp. 5.1 kΩ 5% 1/2 W*	301104
R102	" " " " " " "	301104
R103	" " 1.3 kΩ 5% 1/2 W	301090
R104	" " 100 kΩ 5% 1/2 W	301135
R105	" " " " " " "	301135
R106	" " 5.1 kΩ 5% 1/2 W	301104
R107	" " 1 kΩ 5% 1/2 W	301087
R108	" " " " " " "	301087
R109	" " 2 kΩ 5% 1/2 W	301094
R110	" " 10 kΩ 5% 1/2 W	301111
R111	" " " " " " "	301111
R112	" " " " " " "	301111
R113	" " " " " " "	301111
R114	" MF 1.62 kΩ 1% 3/8 W	340267
R115	" Var. 200 Ω 1/2 W	311304

*Not used after S/N 755

MASTER BOARD

Reference	Description	BEC Part No.
R116	Resistor MF 604 Ω 1% 3/8 W	340213
R117	" " 1.62 kΩ 1% 3/8 W	340267
R118	" Var. 200 Ω 1/2 W	311304
R119	" MF 604 Ω 1% 3/8 W	340213
R121	" Comp. 3.9 kΩ 5% 1/4 W	300096
R122	" " " " " " "	300096
R124	" " 5.1 kΩ 5% 1/4 W	300099
R125	" " " " " " "	300099
R126	" " " " " " "	300099
R127	" " " " " " "	300099
R128	" " " " " " "	300099
R129	" " " " " " "	300099
R130	" " " " " " "	300099
R131	" " " " " " "	300099
R132	" MF 10 kΩ 1% 3/8 W	326376
R133	" Var. 20 kΩ 10% 1 W	311266
R134	" Comp. 4.7 MΩ 5% 1/2 W	301175
R135	" " 10 MΩ 5% 1/2 W	301183
R136	" " 8.2 MΩ 5% 1/2 W	301181
R137	" " 10 kΩ 5% 1/2 W	301111
R138	" MF 63.4 kΩ 1% 3/8 W	340455
R139	" " 10 kΩ 1% 3/8 W	326376
R140	" " 3.65 kΩ 1% 3/8 W	340307
R144	" Var. 200 Ω 10% 1 W	311269
R147	" MF 1.21 kΩ 1% 1/4 W	315089
R148	" Comp. 4.7 kΩ 5% 1/2 W	301103

OSCILLATOR/AMPLIFIER BOARD

Reference	Description	BEC Part No.
A201	Amp. LM301AN	535012
C201	Capacitor Cer. 0.001 µF 500 V	224114
C202	" " Var. 4.5-50 pF (Green)	281006
C203	" Elec. 33 µF 20% 15 V	283206
C204	" Cer. 0.001 µF 500 V	224114
C205	" PE 0.1 µF 10% 100 V	234080
C206	" Cer. 0.001 µF 500 V	224114
C207	" PE 0.1 µF 10% 100 V	234080
C208	" Elec. 33 µF 20% 15 V	283206
C209	" Mica 250 pF 5% 500 V	200036
C210	" " 30 pF 5% 500 V	200073
C211	" Cer. 0.01 µF 100 V	224119
C212	" PE 0.1 µF 10% 100 V	234080
C213	" Mica 160 pF 5% 500 V	200048
C214	" " 82 pF 5% 500 V	200074
C215	" PE 0.1 µF 10% 100 V	234080
C216	" Cer. 0.001 µF 500 V	224114
C217	" PE 0.1 µF 10% 100 V	234080
C218	" Mica 39 pF 5% 500 V	200025
C219	" " " " " " "	200025
C220	" Cer. 0.001 µF 500 V	224114
C221	" PE 0.1 µF 10% 100 V	234080
C222	" " " " " " "	234080

OSCILLATOR/AMPLIFIER BOARD

Reference	Description	BEC Part No.
C223	Capacitor PE 0.1 µF 10% 100 V	234080
C224	" " " " " " "	234080
C225	" " " " " " "	234080
C226	" " " " " " "	234080
C227	" " " " " " "	234080
C228	" Cer. Var. 2.3-20 pF (Blue)	281005
C229	" PE 0.1 µF 10% 100 V	234080
C230	" Mica 680 pF 1% 300 V	200015
C231	" " " " " " "	200015
C232	" " 39 pF 5% 500 V	200025
C233	" Cer. Var. 4.5-50 pF (Green)	281006
C234	" PE 0.022 µF 20% 250 V	234079
C235	" " " " " " "	234079
C236	" Cer. 0.01 µF 100 V	224119
C237	" PE 0.022 µF 20% 250 V	234079
C238	" " " " " " "	234079
C239	" Cer. 0.01 µF 100 V	224119
CR201	Diode Sig. 1N914	530058
CR202	" Zen. 1N5240B	530077
CR203	" Sig. 1N914	530058
CR204	" " "	530058
CR205	" S/F (4) 530124 PED 72-1	530131
CR206	" " " " " "	530131
CR207	" " " " " "	530131
CR208	" " " " " "	530131

OSCILLATOR/AMPLIFIER BOARD

Reference	Description	BEC Part No.
CR209	Diode Sig. 1N914	530058
CR210	" " "	530058
L201	Ind. Var. Unit	400233
L202	Choke 2.2 mH	400141
L203	" " "	400141
Q201	Transistor TIS58	528038
Q202	" 2N5459	528019
Q203	" TIS58	528038
Q204	" 2N5088	528047
Q205	" 40673 S/F 528054 Green	528090
Q206	" 2N2219	528014
Q207	" 40673 S/F 528054 Green	528090
Q208	" 2N3905	528025
Q209	" HDGP-1000	528066
R201	Resistor MF 1.21 kΩ 1% 1/4 W	315089
R202	" Var. 1 kΩ 10% 3/4 W	311226
R203	" MF 8.25 kΩ 1% 3/8 W	326309
R204	" Comp. 2 kΩ 5% 1/2 W	301094
R205	" MF 33.2 kΩ 1% 3/8 W	340421
R206	" Comp. 100 kΩ 5% 1/2 W	301135

OSCILLATOR/AMPLIFIER BOARD

Reference	Description	BEC Part No.
R207	Resistor MF 100 kΩ 1% 3/8 W	326501
R208	" Comp. 12 kΩ 5% 1/2 W	301113
R209	" " 6.8 kΩ 5% 1/2 W	301107
R210	" " 560 kΩ 5% 1/2 W	301153
R211	" " 33 Ω 5% 1/2 W	301051
R212	" " 1 kΩ 5% 1/2 W	301087
R213	" MF 10 Ω 1% 1/4 W	315039
R214	" Comp. 150 kΩ 5% 1/2 W	301139
R215	" " 100 kΩ 5% 1/2 W	301135
R216	" " 2.7 kΩ 5% 1/2 W	301097
R217	" " 820 Ω 5% 1/2 W	301085*
R217	" " 1 kΩ 5% 1/2 W	301087*
*One of the above resistors to be selected during calibration.		
R218	Resistor MF 590 Ω 1% 3/8 W	340212
R219	" Comp. 6.2 kΩ 5% 1/2 W	301106
R220	" " 3.9 kΩ 5% 1/2 W	301101
R221	" " 120 kΩ 5% 1/2 W	301137
R222	" " 47 kΩ 5% 1/2 W	301127
R223	" " 2.2 MΩ 5% 1/2 W	301167
R224	" " 510 Ω 5% 1/2 W	301080
R225	" " 2.4 kΩ 5% 1/2 W	301096
R226	" " 270 Ω 5% 1/2 W	301073
R227	" " 47 Ω 5% 1/2 W	301055
R228	" " 56 Ω 5% 1/2 W	301057

OSCILLATOR/AMPLIFIER BOARD

Reference	Description	BEC Part No.
R229	Resistor Comp. 47 kΩ 5% 1/2 W	301127
R230	" " 560 kΩ 5% 1/2 W	301153
R231	" " 1.5 kΩ 5% 1/2 W	301091
R232	" " 100 Ω 5% 1/2 W	301063
R233	" " 12 kΩ 5% 1/2 W	301113
R234	" MF 2.67 kΩ 1% 3/8 W	340291
R235	" " 49.9 Ω 1% 3/8 W	340084
R236	" Comp. 2 kΩ 5% 1/2 W	301094
R237	" " 2.7 kΩ 5% 1/2 W	301097
R238	" MF Selected from (4) 325396	325399
R239	" " " " " "	325399
R240	" Comp. 10 MΩ 1/2 W	301183
R241	" MF Selected from (4) 325396	325399
R242	" Var. 100 Ω 10% 1 W	311338
R243	" MF Selected from (4) 325396	325399
R244	" Comp. 10 kΩ 5% 1/4 W	300106
RT201	Therm. 50 Ω 10%	325011
T201	Phase Sens. Det. XFMR Unit	400235
T202	Amp. Output XFMR Unit	400265
Y201	Crystal 1 MHz	547020

DIGITAL CONTROL BOARD

Reference	Description	BEC Part No.
C301	Capacitor Elec. 10 µF 20% 20 V	283205
C302	" Mica 33 pF 5% 500 V	200049
C303	" " 1000 pF 5% 100 V	200505
C304	" Elec. 10 µF 20% 20 V	283205
C305	" PE 100 nF 10% 100 V	234080
C306	" " " " " " "	234080
C307	" Mica 1000 pF 5% 100 V	200505
C308	" PE 100 nF 10% 100 V	234080
CR301	Diode Sig. 1N914	530058
CR302	" Zen. 1N5227B	530095
CR303	" " "	530095
CR304	" Sig. 1N914	530058
CR305	" " "	530058
IC301	I.C. SN74123N	534071
IC302	" " SN74L86N	534069
IC303	Amp. LM301AN	535012
IC304	" "	535012
IC305	" "	535012
IC306	" "	535012
IC307	" "	535012
IC308	I.C. CD4016AE	534007
IC309	" " SN74L73N	534070

DIGITAL CONTROL BOARD

Reference	Description	BEC Part No.
IC310	I.C. SN7402N	534027
IC311	" " SN74L74N	534003
IC312	" " SN74L00N	534002
IC313	" " N8471A	534005
IC314	" " "	534005
Q301	Transistor 2N5653	528056
R301	Resistor Comp. 39 kΩ 5% 1/2 W	301125
R302	" " 4.7 kΩ 5% 1/2 W	301103
R303	" " " " " " "	301103
R304	" MF 15 kΩ 1% 3/8 W	340378
R305	" " " " " " "	340378
R306	" " 12.7 kΩ 1% 3/8 W	340372
R307	" " " " " " "	340372
R308	" " 90.9 Ω 1% 3/8 W	340115
R309	" " 110 Ω 1% 1/4 W	340125
R310	" " 1 kΩ 1% 3/8 W	340239
R311	" " " " " " "	340239
R312	" Comp. 39 kΩ 5% 1/2 W	301125
R313	" " 1 MΩ 5% 1/2 W	301159
R314	" " 51 kΩ 5% 1/2 W	301128
R315	" " 100 Ω 5% 1/2 W	301063

DIGITAL CONTROL BOARD

Reference	Description	BEC Part No.
R316	Resistor Var. 200 Ω 10% 1/2 W	311339
R317	" " " " " " "	311339
R318	" Comp. 100 Ω 5% 1/2 W	301063
R319	" " 4.7 kΩ 5% 1/2 W	301103
R320	" " " " " " "	301103
R321	" " " " " " "	301103
R322	" " " " " " "	301103
R323	" " " " " " "	301103
R324	" " " " " " "	301103
R325	" " 10 kΩ 5% 1/4 W	300106
R326	" " 470 kΩ 5% 1/4 W	300146

DIGITAL PANEL METER

Reference	Description	BEC Part No.
A1401	Op Amp Follower LM310 Only	535005
A1402	Op Amp LM301AN	535012
A1403	Op Amp Follower LM310 Only	535005
A1404	Op Amp Comparator LM311	535006
C1201	Capacitor Elec. 200 µF 6 V	283147
C1202	" Mica 120 pF 500 V 5%	200002*
C1202	" " 56 pF 500 V 5%	200030*
C1202	" " 150 pF 500 V 5%	200032*
C1202	" " 91 pF 500 V 5%	200035*
C1202	" " 33 pF 500 V 5%	200049*
	*One of the Above to be Selected During Calibration.	
C1203	Capacitor Var. 4.5-50 pF 250 V	281009
C1204	" Mica 33 pF 500 V 5%	200049
C1205	" Myl. 10 nF 250 V 20%	234085
C1206	" " 100 nF 250 V 20%	234080
C1207	" Cer. 33 pF 100 V 10%	224218
C1208	" Elec. 10 µF 20 V 20%	283205
C1209	" " " " " " "	283205
C1401	" " 1 µF 35 V 20%	283199
C1402	" " " " " " "	283199
C1403	" PC 100 nF 50 V 10%	234046

DIGITAL PANEL METER

Reference	Description	BEC Part No.
C1404	Capacitor Cer. 33 pF 500 V 5%	224139
C1405	" Elec. 1 µF 35 V 20%	283199
C1406	" PC 100 nF 50 V 10%	234046
CR1201	Diode Zen. 1N5234B	530093
CR1202	" " "	530093
CR1203	" Sig. 1N914	530058
CR1204	" " "	530058
CR1301	" " 1N914	530058
CR1302	" " "	530058
CR1303	" " "	530058
CR1304	" " "	530058
CR1401	" Zen. 1N821	530050
CR1402	" " "	530050
CR1403	" Sig. 1N914	530058
CR1404	" " "	530058
CR1405	" " "	530058
DS1301	Numeric Display HP 5082-7730	536802
DS1302	" " " "	536802

DIGITAL PANEL METER

Reference	Description	BEC Part No.
DS1303	Numeric Display HP 5082-7730	536802
DS1304	Lamp #2200D	545120
DS1305	" "	545120
DS1306	" "	545120
DS1307	" "	545120
DS1308	Numeric Display HP 5082-7730	536802
DS1309	Lamp #2200D	545120
DS1310	" "	545120
DS1311	" "	545120
IC1201	Nand Gate 74L00N	534002
IC1202	Decade Counter MK5002P	534024
IC1401	Quad Switch CD4016AE	534007
IC1402	Dual "D" Binary CD4013AE	534021
IC1403	Nand Gate CD4011AE	534022
IC1404	Nor Gate CD4001AE	534023
J1202	Connector 6 Pos. P.C.	479277
J1203	" " " "	479277
J1204	" " " "	479277

DIGITAL PANEL METER

Reference	Description	BEC Part No.
Q1201	Transistor PNP MPS6516	528037
Q1202	" " "	528037
Q1203	" " "	528037
Q1204	" " "	528037
Q1205	" " "	528037
Q1206	" " "	528037
Q1207	" " "	528037
Q1208	" " "	528037
Q1209	" NPN MPS6507	528070
Q1210	" " MPS6512	528059
Q1211	" " "	528059
Q1212	" " "	528059
Q1213	" PNP 2N5087	528042
Q1214	" NPN MPS6512	528059
Q1215	" PNP 2N5087	528042
Q1216	" " "	528042
Q1217	" " "	528042
Q1218	" " "	528042
Q1219	" NPN MPS6512	528059
Q1220	" Unj. MPU 131	528062
Q1221	" PNP 2N5087	528042
Q1222	" " "	528042
Q1223	" " "	528042
Q1224	" " "	528042

DIGITAL PANEL METER

Reference	Description	BEC Part No.
Q1301	Transistor NPN MPS6512	528059
Q1302	" " "	528059
Q1303	" " "	528059
Q1304	" " "	528059
Q1305	" " "	528059
Q1306	" " "	528059
Q1307	" " "	528059
Q1308	" MPSA12	528052
Q1309	" "	528052
Q1310	" "	528052
Q1311	" "	528052
Q1312	" PNP 2N5087	528042
Q1401	" Selected M/F 528038 PED 93-1	528068
R1201	Resistor Comp. 27 kΩ 5% 1/4 W	300116
R1202	" " " " " " "	300116
R1203	" " " " " " "	300116
R1204	" " " " " " "	300116
R1205	" " " " " " "	300116
R1206	" " " " " " "	300116
R1207	" " 2 kΩ 5% 1/4 W	300089
R1208	" " 1 kΩ 5% 1/4 W	300082
R1209	" " 5.1 kΩ 5% 1/4 W	300099
R1210	" " " " " " "	300099

DIGITAL PANEL METER

Reference	Description	BEC Part No.
R1211	Resistor Comp. 100 kΩ 5% 1/4 W	300130
R1212	" " " " " " "	300130
R1213	" " " " " " "	300130
R1214	" " " " " " "	300130
R1215	" " 27 kΩ 5% 1/4 W	300116
R1216	" " 5.1 kΩ 5% 1/4 W	300099
R1217	" " " " " " "	300099
R1218	" " " " " " "	300099
R1219	" " " " " " "	300099
R1220	" " " " " " "	300099
R1221	" " 27 kΩ 5% 1/4 W	300116
R1222	" " " " " " "	300116
R1223	" " 680 Ω 5% 1/4 W	300078
R1224	" " 430 Ω 5% 1/4 W	300073
R1225	" " 680 kΩ 5% 1/4 W	300150
R1226	" " 100 kΩ 5% 1/4 W	300130
R1227	" " 680 kΩ 5% 1/4 W	300150
R1228	" " 5.1 kΩ 5% 1/4 W	300099
R1229	" " 330 Ω 5% 1/4 W	300070
R1230	" " 4.7 MΩ 5% 1/4 W	300170
R1231	" " 5.1 kΩ 5% 1/4 W	300099
R1232	" " " " " " "	300099
R1233	" " " " " " "	300099
R1234	" " " " " " "	300099
R1235	" " 430 Ω 5% 1/4 W	300073

DIGITAL PANEL METER

Reference	Description	BEC Part No.
R1301	Resistor Comp. 47 Ω 5% 1/4 W	300050
R1302	" " " " " " "	300050
R1303	" " " " " " "	300050
R1304	" " " " " " "	300050
R1305	" " " " " " "	300050
R1306	" " " " " " "	300050
R1307	" " " " " " "	300050
R1308	" " 27 kΩ 5% 1/4 W	300116
R1309	" " " " " " "	300116
R1310	" " " " " " "	300116
R1311	" " " " " " "	300116
R1312	" " 33 Ω 5% 1/4 W	300046
R1401	" MF 30.9 kΩ 1% 1/4 W	325461
R1402	" " " " " " "	325461
R1403	" " 5.49 kΩ 1% 1/4 W	325398
R1404	" " " " " " "	325398
R1405	" Var. 5 kΩ 20% 0.5 W	311293
R1406	" MF 1.15 kΩ 1% 1/4 W	325377
R1407	" " 200 kΩ 1% 1/4 W	325585
R1408	" Var. 5 kΩ 20% 0.5 W	311293
R1409	" Comp. 330 Ω 5% 1/4 W	300070
R1410	" " 10 kΩ 5% 1/4 W	300106
R1411	" MF 1.15 kΩ 1% 1/4 W	325377
R1412	" Comp. 27 kΩ 5% 1/4 W	300116

DIGITAL PANEL METER

Reference	Description	BEC Part No.
R1413	Resistor Comp. 4.7 MΩ 5% 1/4 W	300170
R1414	" " 680 Ω 5% 1/4 W	300078
R1415	" " 27 kΩ 5% 1/4 W	300116
R1416	" " 5.1 kΩ 5% 1/4 W	300099
R1417	" " 10 kΩ 5% 1/4 W	300106
R1418	" " 4.7 MΩ 5% 1/4 W	300170
R1419	" " 1 MΩ 5% 1/4 W	300154
R1420	" " 47 kΩ 5% 1/4 W	300122

FRONT PANEL

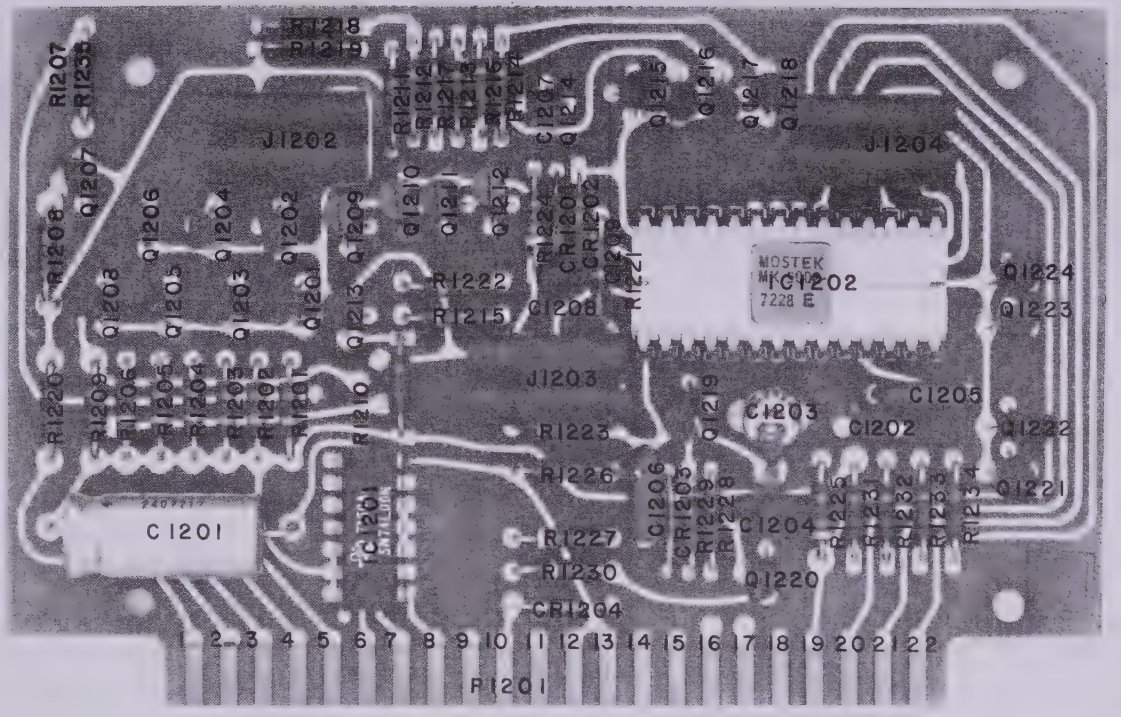
Reference	Description	BEC Part No.
C404	Capacitor Var. 1.8-8.7 pF	275138
C405	" Elec. 10 µF 20% 20 V	283205
IC401	I.C. µA 7805	535011
S401, DS401	Switch On/Off & Pilot Light	465165
S403	Switch P. B.	465164
T401	Oscillator Transformer Assembly	072006-3

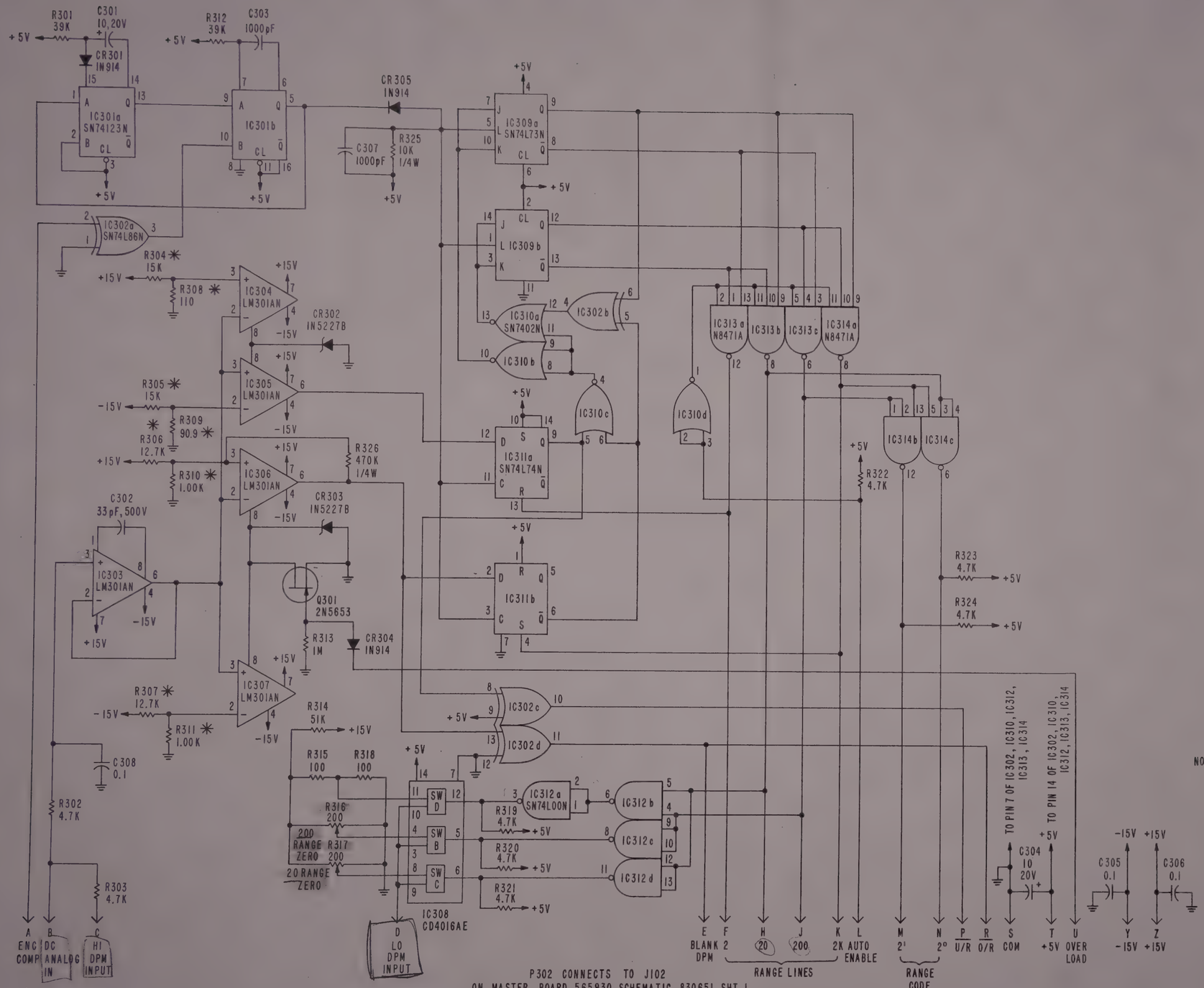
OSCILLATOR TRANSFORMER

C401	Capacitor Mica 560 pF 1% 300 V	200091

REAR PANEL

Reference	Description	BEC Part No.
C402	Capacitor Cer. 0.01 μF 20% 1000 V	224228
C403	" " " " " " "	224228
F401	Fuse 0.25 A (120 V)	545511
F401	Fuse 0.12 A (240 V)	545516
F402	Fuse 1/32 A 250 V AGC	545525
F403	" " " " " "	545525
J401	Connector 6 Pin	479255
J404	" " "	479255
P401	Connector, Line Cord	477281
R401	Resistor Comp. 510 kΩ 5% 1/2 W	301152
R402	" " 240 kΩ 5% 1/2 W	301144
S402	Switch	466230
T402	Transformer, Power	466071


R1218
R1219
R1207
R1238
J1202
J1204
MOSTEK
MK
7228 E
IC1202
Q1224
Q1223
Q1222
Q1221
J1203
C1205
C1203
C1202
C1201
IC1201
SANTELOON
C1204
Q1220
CR1204
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
P1201

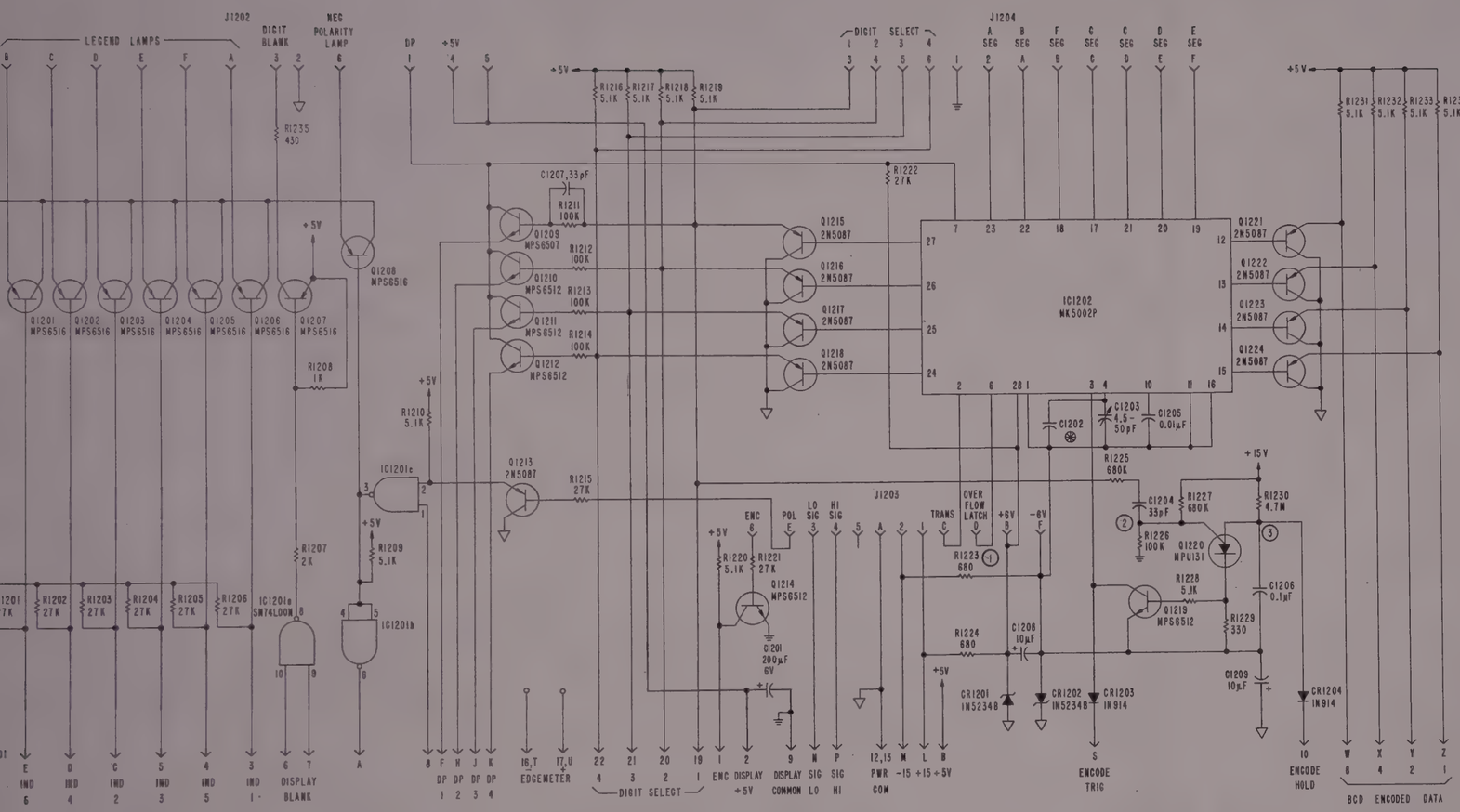


NOTES:

1. CAPACITANCE VALUES IN μF AND 100V UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS, 3/8 WATT.
4. LAST NUMBERS USED:
   R326 C308

BOONTON ELECTRONICS CORPORATION

MODEL 72BD
Schematic, Digital Control
D830651C Sheet 3 of 3



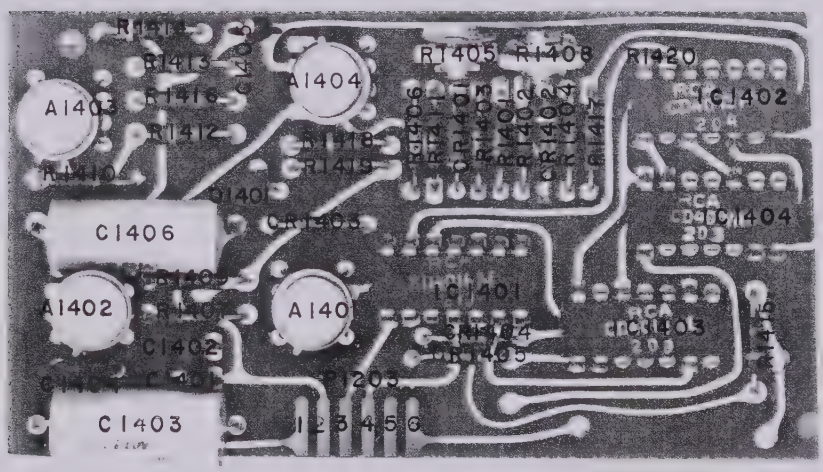
TEST POINT ① ② ③

WAVEFORM

S:
RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
FACTORY SELECTED.
TEST CONDITIONS:
ALL MEASUREMENTS MADE WITH +0.5 V INPUT.
ALL VALUES NOMINAL.
LAST NUMBERS USED:
R1235 C1209 Q1224
COMMON

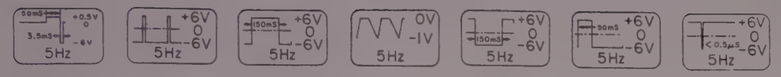
BOONTON ELECTRONICS CORPORATION

MODEL DPM
Schematic, Counter Board
E830546C Sheet 1 of 3


R1418
R1413
R1416
R1412
R1410
A1403
A1404
R1405
R1408
R1420
IC1402
R1418
R1415
Q1401
C1406
C-R1403
C1404
A1402
A1401
IC1401
C1402
C1407
C1405
R1203
C1403
1 2 3 4 5 6

TEST POINT ① ② ③ ④ ⑤ ⑥ ⑦

WAVEFORM



C1403 0.1µF 50V
R1413 4.7M
+15V
A1404 LM311
R1417 10K
+6V
R1420 47K
C1404 33pF
R1418 4.7M
R1407 200K
A1401 LM310
R1414 680
C1405 1µF
-6V
-15V
A1402 LM301A
+15V -15V
R1410 10K
-15V +15V
A1403 LM310
R1416 5.1K
R1409 330
R1412 27K
C1406 0.1µF 50V
Q1401 TIS58
R1419 1M
+15V -15V
CR1403 IN914
IC1401 CD4016AE
R1404 5.49K
R1408 5K
+6.2 V
IC1402a CD4013AE
IC1403a CD4011AE
IC1403b
IC1403c
IC1404b
IC1404c
IC1404d
IC1402b
R1403 5.49K
R1405 5K
-6.2 V
CR1401 IN821
CR1402 IN821
R1406 1.15K
R1411 1.15K
R1401 30.9K
R1402 30.9K
CR1404 IN914
CR1405 IN914
-15V +15V
-6V
R1415 27K
IC1403d
IC1404a CD4001AE
C1401 1µF 35V
C1402 1µF 35V
+6V = NEG. SIGNAL
-6V = POS. SIGNAL
P1203
HI LO SIGNAL
-15V COM +15V
OVERFLOW LATCH
ENCODE
TRANSFER
POLARITY

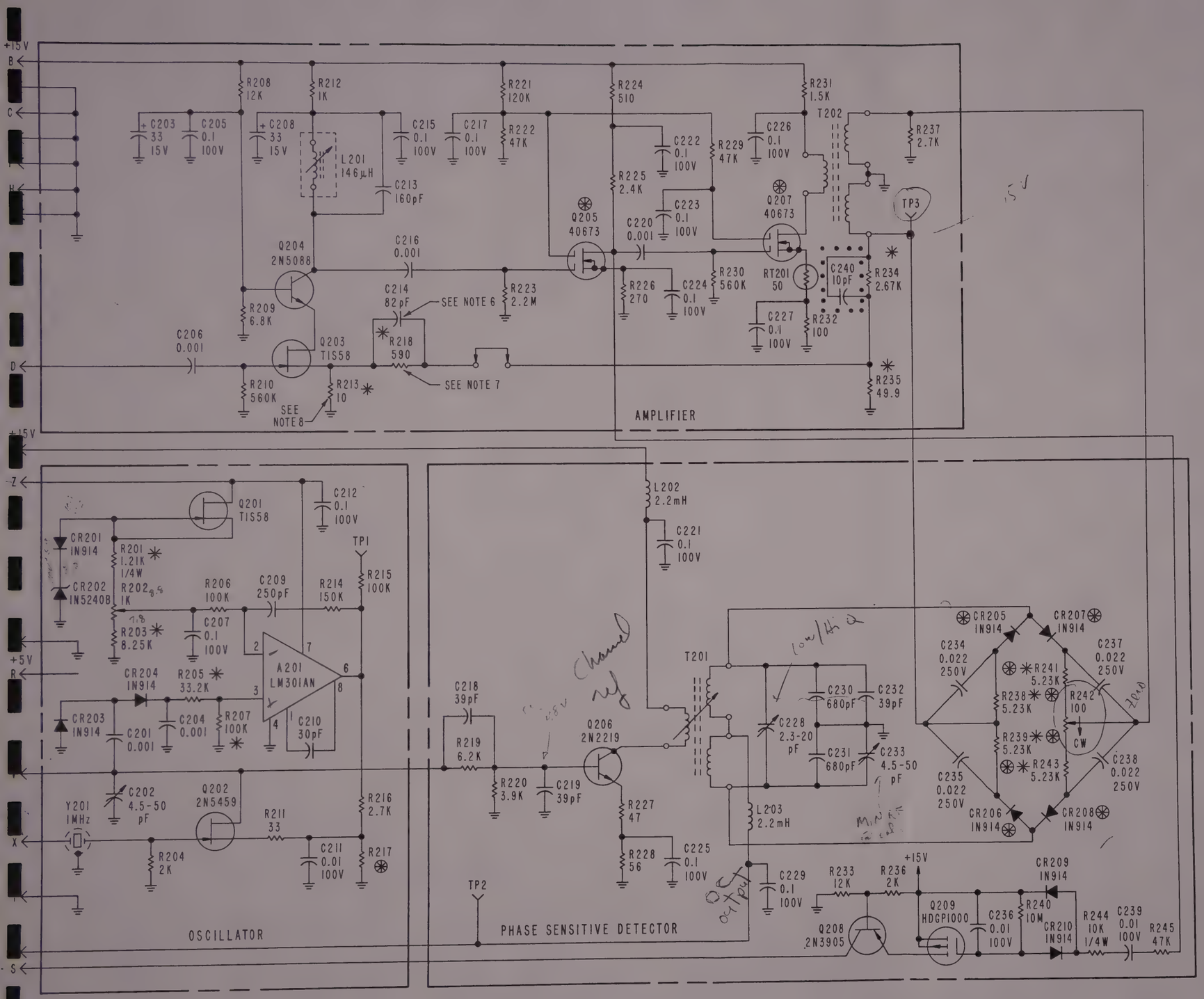
NOTES:

1. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
2. ✳ PRECISION RESISTOR.
3. TEST CONDITIONS:
   ALL MEASUREMENTS MADE WITH +0.5 Vdc INPUT.
   ALL VALUES NOMINAL.
4. LAST NUMBERS USED:
   R1420 C1406

BOONTON ELECTRONICS CORPORATION

MODEL DPM
Schematic, Aid Converter
D830546B (Sheet 3 of 3)

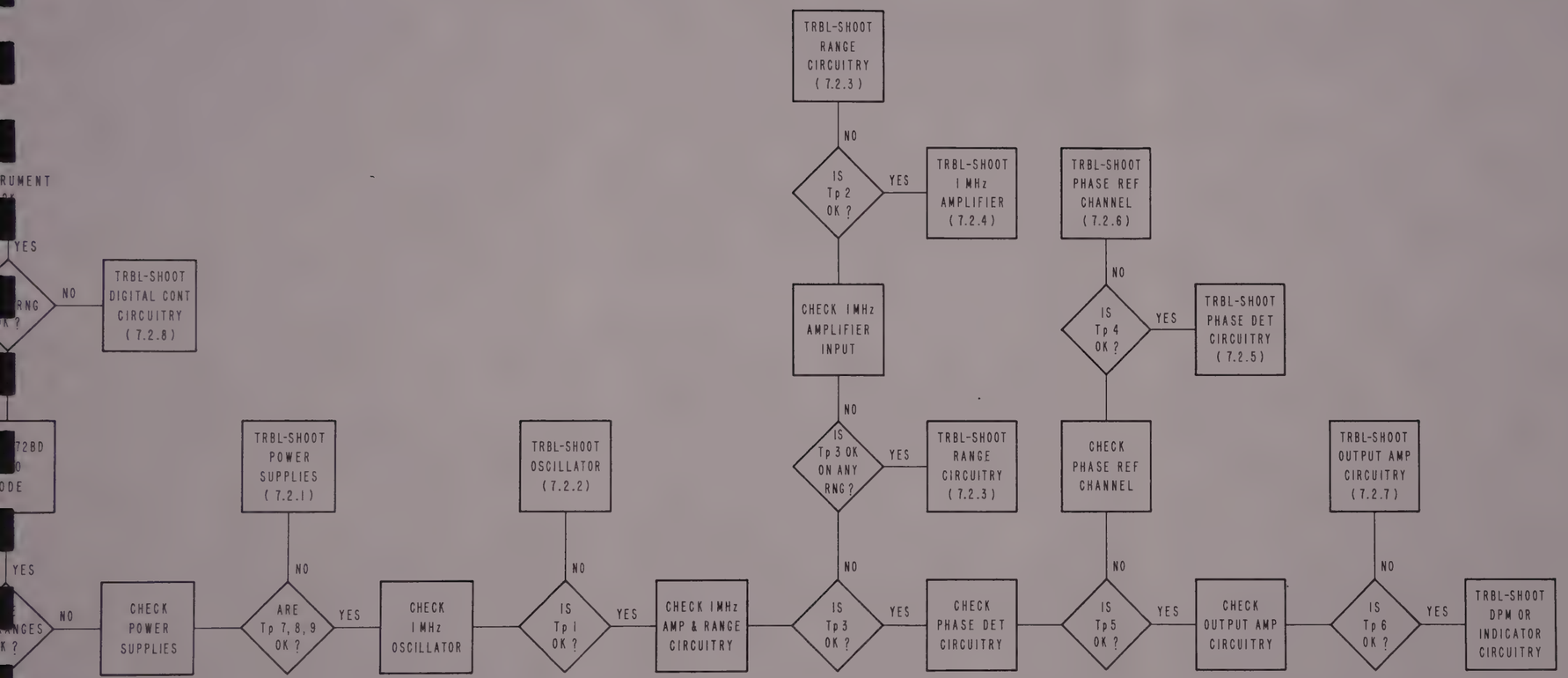
TP1
R201
Q201
R202
CR202
CR201
C209
C210
C202
R203
R207
A201
R214
R215
R206
C207
CR203
C204
R205
CR204
R216
C201
R217
R211
C212
C228
C211
C219
R220
R219
C218
Q202
C221
C225
R204
C233
R227
R228
L202
R238
Q206
T201
R239
C235
Y201
TP3
CR206
C234
CR205
CR207
C231
C230
C232
C237
CR208
L203
C229
C238
R241
CR209
R243
CR210
R240
C236
R236
R233
R242
R244
Q209
Q208
C239
TP2
R237
R245
T202
R213
C226
R218
R235
C214
R234
R231
R232
L201
C227
R226
C224
Q204
Q203
RT201
C223
Q207
C220
R225
Q205
C216
C213
C206
R229
R230
C222
C217
C208
C215
R209
C203
C205
R210
R224
R221
R222
R223
R212
R208



1. CAPACITANCE VALUES IN µF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS & 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS, 3/8 WATT.
4. ⊛ FACTORY SELECTED.
5. LAST NUMBERS USED: R245 C240
6. ON 72B-03 THIS VALUE IS 430pF.
7. ON 72B-03 THIS VALUE IS 60.4 .
8. ON 72B-03 THIS VALUE IS 13 .
9. ⋯ SIGNIFIES COMPONENT ADDED FOR 72B-03.

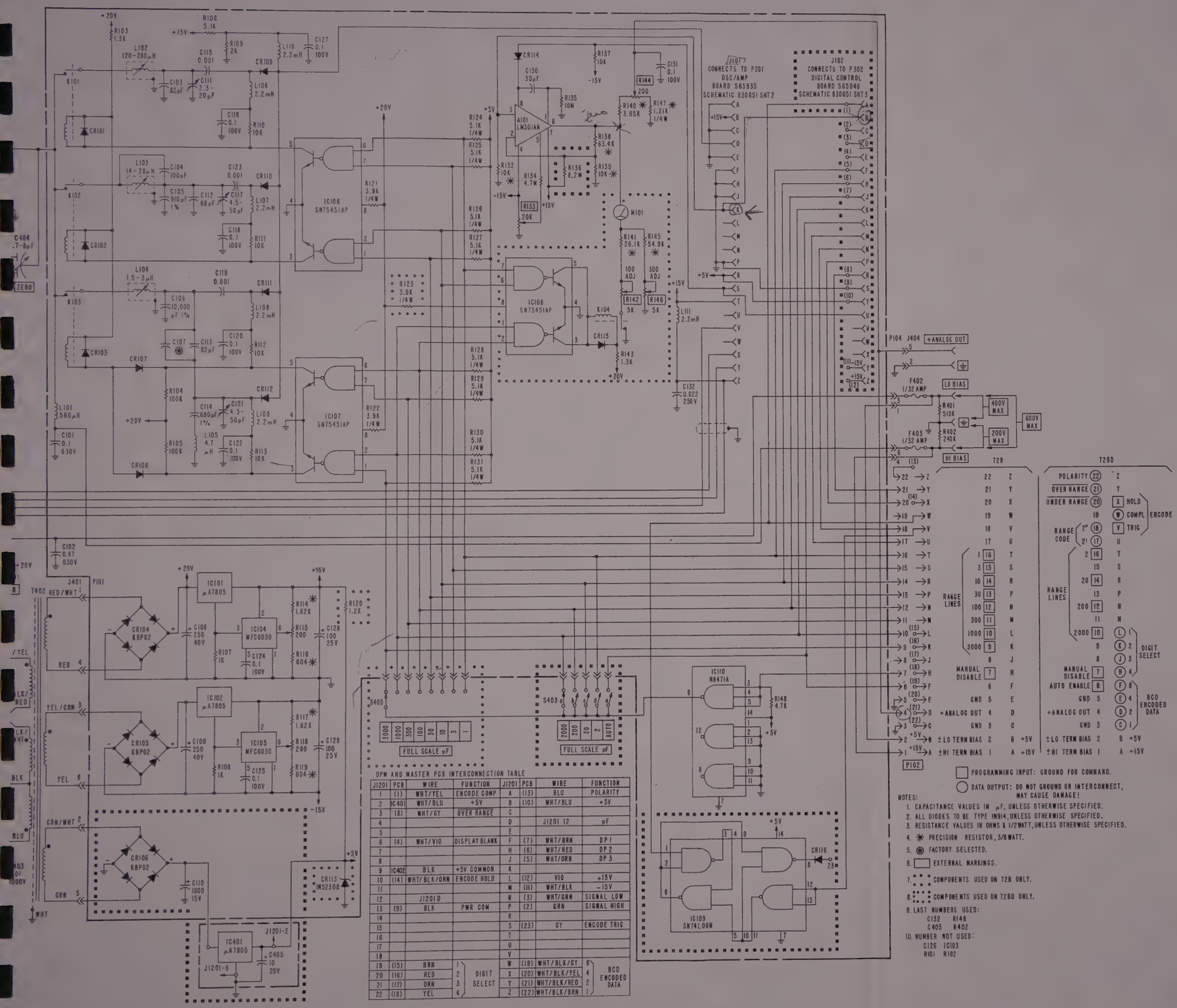
BOONTON ELECTRONICS CORPORATION

MODEL 72B, 72BD, 72B-03
Schematic Osc./Amp.
D830651D Sheet 2 of 3



BOONTON ELECTRONICS CORPORATION

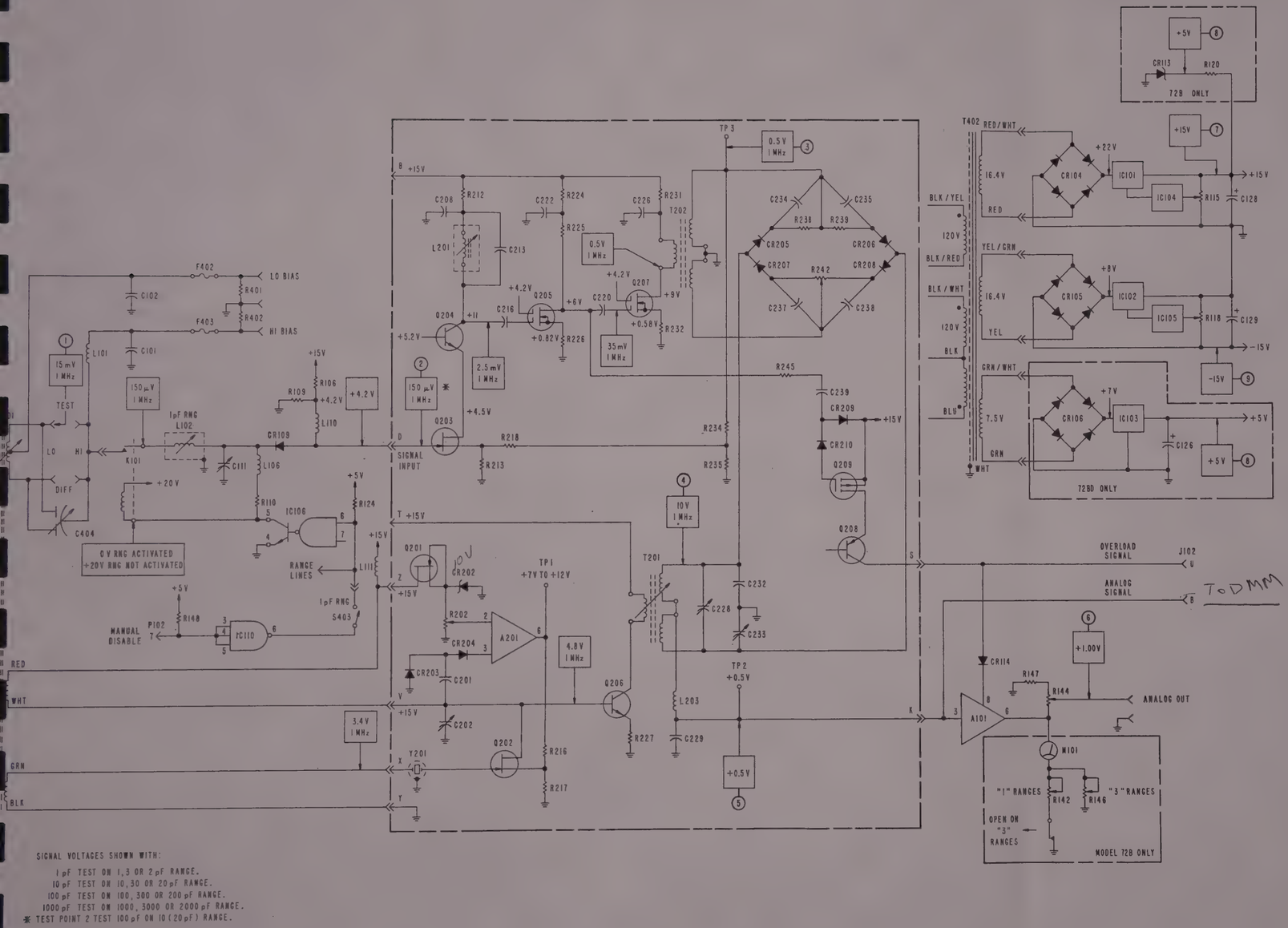
MODEL 72B, 72BD
BLOCK DIAGRAM
D830716A



BOONTON ELECTRONICS CORPORATION

MODEL 72B, 72BD
Schematic, Trouble Shoot
E830715B

J1201
C111
C103
C105
C112
C117
C121
C114
L105
L110
C127
R109
R106
CR116
C115
CR109
L106
C123
CR110
C106
C119
CR111
C107
C113
CR112
C116
C104
C118
L107
L108
L109
C120
C122
J101
J102
L102
L103
L104
R110
R111
R112
R113
P104
K101
CR101
K102
CR102
K103
CR103
CR107
R104
CR108
R105
R103
C110
C129
C128
R121
R122
IC106
IC107
R118
R119
C109
R127
R126
R125
R124
R131
R130
R129
R128
R108
IC105
R117
C125
R116
IC102
R115
C132
L111
C108
IC101
R107
IC104
R114
C124
P101
IC110
R148
CR114
R135
R140
R138
R139
R136
R132
C130
A101
C102
C101
L101



SIGNAL VOLTAGES SHOWN WITH:

1 pF TEST ON 1, 3 OR 2 pF RANGE.
10 pF TEST ON 10, 30 OR 20 pF RANGE.
100 pF TEST ON 100, 300 OR 200 pF RANGE.
1000 pF TEST ON 1000, 3000 OR 2000 pF RANGE.
* TEST POINT 2 TEST 100 pF ON 10 (20 pF) RANGE.

BOONTON ELECTRONICS CORPORATION

MODEL 72B, 72BD
Schematic Master
E830651D Sheet 1 of 3

Q1302
Q1303
Q1304
Q1305
Q1306
Q1307
Q1308
Q1309
Q1310
DS1305
DS1309
DS1307
DS1306
DS1304
DS1301
DS1302
DS1303
DS1308
P1304
P1302
1 2 3 4 5 6
1 2 3 4 5 6

DS1301 HP5082-7730
DS1302 HP5082-7730
DS1303 HP5082-7730
DS1308 HP5082-7730

R1302 47 R1303 47 R1304 47 R1305 47 R1306 47 R1307 47

Q1308 MPSA12 Q1309 MPSA12 Q1310 MPSA12 Q1311 MPSA12

R1311 27K

R1312 33

Q1312 2N5087

DS1304 2200D DS1305 2200D DS1306 2200D DS1307 2200D DS1309 2200D DS1310 2200D DS1311 2200D

+5V

R1308 27K R1309 27K R1310 27K

Q1302 MPS6512 Q1303 MPS6512 Q1304 MPS6512 Q1305 MPS6512 Q1306 MPS6512 Q1307 MPS6512

CR1301 IN914 CR1302 IN914 CR1303 IN914 CR1304 IN914

A B F G C D E F

SEGMENT SELECT

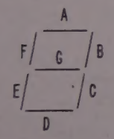
6 MS 5 4 3 LS DIGIT SELECT

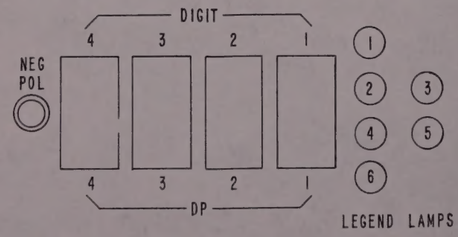
3 DIGIT BLANK 2 COM 1 DP 6 NEG POL A IND 1 B IND 6 C IND 4 D IND 2 E IND 3 F IND 5 LEGEND LAMPS

4 5 +5V

P1204

P1202



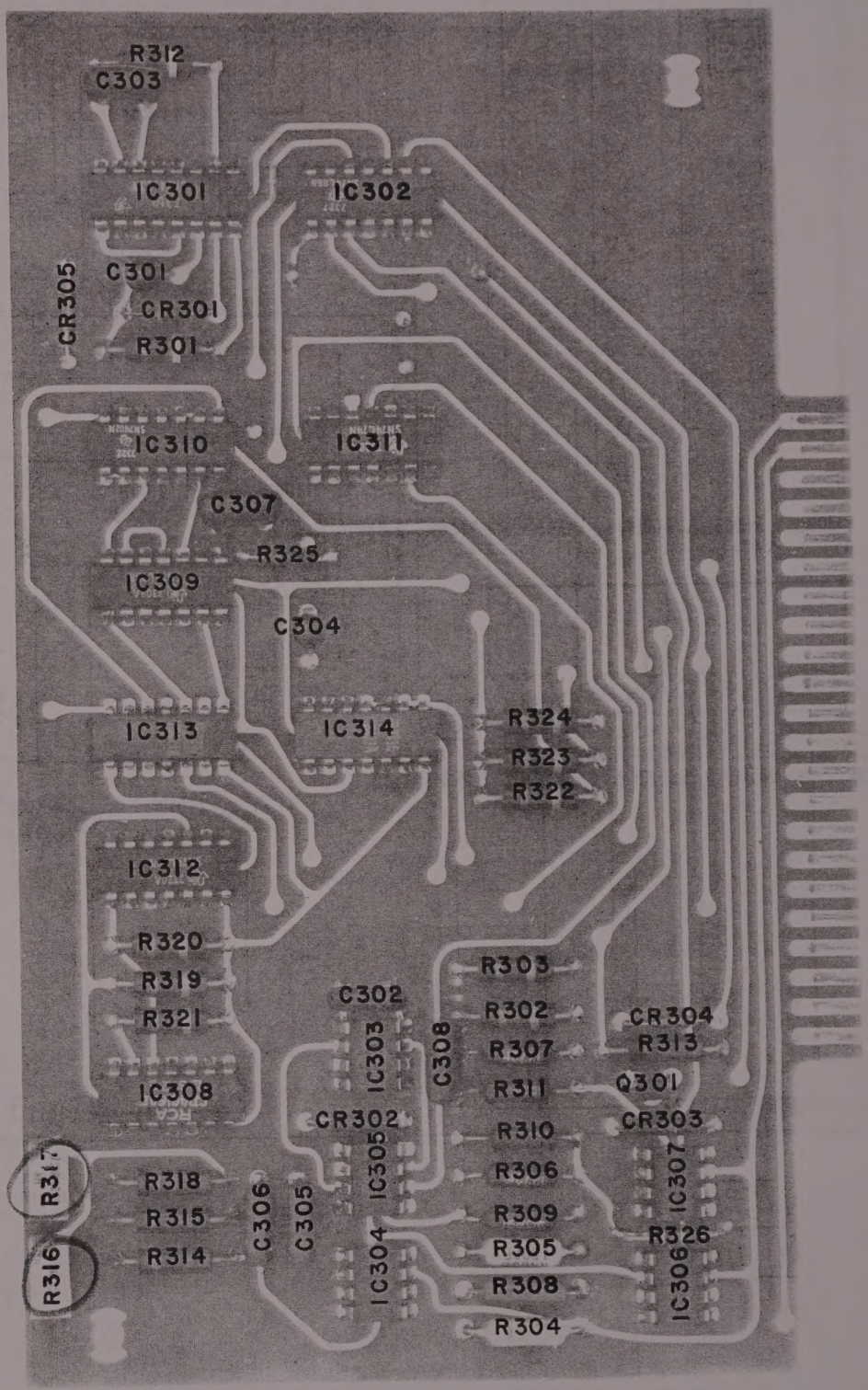


RESISTANCE VALUES IN OHMS AND 1/4WATT, UNLESS OTHERWISE SPECIFIED.

TEST NUMBERS USED:
R1312 Q1311 DS1311

BOONTON ELECTRONICS CORPORATION

MODEL DPM
Schematic,DISPLAY BOARD
D830546D (Sheet 2 of 3)


R312
C303
IC301
IC302
C301
CR305
CR301
R301
IC310
IC311
C307
R325
IC309
C304
IC313
IC314
R324
R323
R322
IC312
R320
R319
R321
IC308
R303
C302
R302
CR304
R313
C308
IC303
R307
Q301
R311
CR302
CR303
R310
R317
R318
R306
IC305
R315
C306
C305
R309
R326
R316
R314
R305
IC307
R308
IC304
IC306
R304

MP MASTER
MA24742